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THE CZECHOSLOVAK PRIVATIZATION AUCTION: AN EMPIRICAL INVESTIGATION

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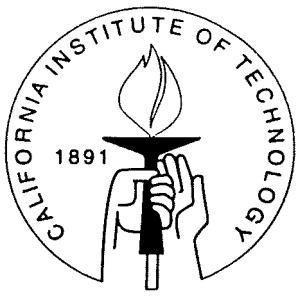

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Abstract

The 1992 Czechoslovak mass-privatization program resembled a multiround Walrasian auction with *tatonnement* in which participants, endowed with points, bid simultaneously for non-uniform products, *i.e.*, shares. The creation of this artificial primary market provides economists with a unique opportunity to investigate empirically 1) the role of the auctioneer in a politically-motivated giveaway scheme, 2) the price-setting mechanism, and 3) the bidding strategies and rationality of the auction's participants. The paper analyzes the information content of the prices that emerged from the bidding process and considers the usefulness of the auction as a mechanism to reveal value. Unlike more conventional auctions, price discovery was only a secondary motive to the auctioneer in this case. The auctioneer's principal aim was to transfer the shares quickly to the investing public in a politically acceptable manner. The evidence shows that the price-updating rules adopted after each bidding round did achieve the auctioneer's principal aim, but also served to inject noise. The results suggest an inherent tradeoff between socially acceptable outcomes in such auctions and efficient price discovery.

Key words: Privatization, Auctions, Economic transition

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1 Introduction

Privatization efforts in the former Soviet bloc differ markedly from those in advanced market economies, not only in scale but in process. The classic method of Western privatization, the public offering, is rarely used in Eastern Europe because of underdeveloped capital markets, inadequate domestic savings, and the prohibitively high costs of taking thousands of companies to market. Instead, to overcome these problems, to speed the pace of market reforms, and to build political support for private ownership, several governments have adopted voucher-based mass-privatization programs. This paper examines the first wave of voucher privatization in the former Czechoslovakia.

As Boycko, Shleifer, and Vishny (1994) discuss in their analysis of the Russian program, the justification for mass privatization is largely political. Indeed, the Czechoslovak government, in the information handbook it distributed to the general public during that country's voucher privatization, emphasized the need to break up the state's monopoly on employment and ownership as a precondition for the "democratic functioning of society" (Federal Ministry of Finance, 1992, p. 6). The principal advantage of mass, or voucher, privatization, however, is that it gives a large cross-section of the population a sense of ownership in the economy and, therefore, a stake in economic reform. It builds political legitimacy for private ownership and helps overcome the tragic dual legacies of communism and the corrupt, spontaneous privatizations that plague countries in the early phases of their transition programs.

Governments also offer economic rationales in support of mass privatization, but these arguments differ little from those of privatization programs elsewhere, namely, better managerial incentives, improved corporate governance, and budgetary relief for governments. Another potential economic advantage, sale proceeds to pay off a country's external debt or to fund social programs, is lacking in mass privatization because of the modest price that citizens pay to participate. From an administrative point of view, however, voucher programs offer an important advantage over conventional forms of privatization. By selling companies for vouchers, governments largely sidestep the valuation problems that plague privatization in transition economies. Valuation is an easier task with voucher-based privatization than under a conventional approach because investors need only assess the enterprises' *relative* values--*i.e.*, their values with respect to one another--rather than having to express all company values in monetary terms. Governments can thus avoid the cost and time delays required to value thousands of companies under conditions of profound political and economic uncertainties and poorly developed capital markets.

The Czechoslovak government's response to the challenge of transferring assets with a book value of US$10.6 billion to the country's citizens was to organize an artificial primary market, centered on a quasi-Walrasian auction with *tatonnement*, in which participants, endowed with points, bid simultaneously for shares in 1,491 companies over five sequential rounds. The demand for shares originated from two distinct groups, investment funds and individuals, and the demand of each group was observable. The

unique cross-sectional and time-series data that emerged from this auction allow one to study the price-formation process and the discovery of value in a market environment populated by informed investors and noise traders, and one in which price discovery is not the principal aim of the auction.

The empirical evidence suggests that the auctioneer deliberately overpriced the shares in the interest of absorbing points but would occasionally underprice to speed up the sale of the least-demanded securities. Mispricing provided the auctioneer a simple device to control the speed at which points were absorbed and assets transferred. The auction participants, especially the investment funds, responded rationally by seeking out underpriced securities. Except in the first round, when all companies were priced identically, demand largely reflected the reaction of investors to the noise injected into the auction by the auctioneer's idiosyncratic repricing rules. In later rounds, bidding behavior can best be described as the search for mispriced securities. The result was the accumulation of non-uniform pricing errors during the bidding rounds.

This paper is organized as follows. The auction mechanism is discussed in section 2. An empirical profile of the participating firms and evidence on the outcome of the auction are presented in section 3. The price-updating rules are examined in section 4, followed by participants' bidding strategies in section 5. Finally, the information content of prices is analyzed in section 6. Section 7 concludes the paper.

2 The Czechoslovak privatization process

2.1 The political environment

The privatization component of the government's reform program had three principal elements: Reprivatization, "small privatization," and "large privatization." Reprivatization, or restitution, returned property that had been nationalized during the communist era. Small privatization focused on shops, restaurants, and small businesses and was managed primarily through public auctions.

All state enterprises not specifically excluded from privatization or designated for sale in small privatization auctions were included in the large privatization program. Large privatization was to occur in two "waves"--the first in 1992 and the second in 1993. The first wave, which is the focus of this paper, took place as scheduled. On January 1, 1993, before the second wave could be implemented, Czechoslovakia split into two sovereign entities. Implementing their own second wave was left to the newly independent states; the Czech Republic implemented a second wave in 1994.

2.2 The auction mechanism

2.2.1. The supply of shares

The supervising ministry of each enterprise designated for inclusion in the first wave was responsible for preparing a "basic project," *i.e.*, privatization plan, for the enterprise by the

end of October 1991.[1] Other interested parties, including foreign investors, could submit their own plans, or "competing projects," by January 20, 1992.

After the privatization projects were submitted to the supervising ministry, they were forwarded, with the ministry's recommendations, to one of the republic's privatization ministries or the federal Ministry of Finance, depending on which political entity--the Czech lands, Slovakia, or the federal state--was deemed to be the owner of that enterprise. These ministries then decided which projects would be accepted.[2] The approval process is summarized in Figure 1.

Designers of privatization projects could select from a menu of options, including direct sales to foreign or domestic investors, transfers of shares to local authorities, transfers to pension or health-care institutions, and temporary retention by one of the three national property funds.[3] Sales of shares to employees were allowed but only within tight limits. Companies also had to set aside at least 3 percent of the shares for a restitution fund. In all cases, voucher privatization was the default option. For example, if a plan called for 15 percent of a company's equity to be sold to a local investor and 25 percent to a foreign investor, and no other privatization option was chosen, after deducting 3 percent for restitution, the remaining 57 percent would be sold through the voucher program. The percentage of total equity privatized with vouchers would vary, therefore, from company to company. For Czech (Slovak) companies participating in the voucher program, about 62 (74) percent of total company share capital was privatized with vouchers.

The voucher program in the first wave was managed by the federal Ministry of Finance's Center for Coupon Privatization (CPP). On May 13, 1992, the CPP published a list of 1,491 participating companies with share capital of about 300 billion korun, or approximately US$10.6 billion. With a nominal share value of 1,000 korun, the number of shares assigned to a particular firm after its conversion into a joint-stock company depended on its total share capital.[4]

2.2.2 The endowments and the *numeraire*

Participation in the voucher privatization program was limited to Czechoslovak citizens 18 years or older and cost 1,035 korun: 35 korun for a voucher booklet and a 1,000-korun registration fee, or about US$35, equivalent to the average weekly wage. Voucher registration took place between October 1991 and February 1992, and secondary trading was strictly forbidden. The vouchers, alternatively known as coupons, were denominated in "points," rather than korun, because of the government's wish to avoid the appearance of creating a substitute currency.[5] Each booklet in the Czechoslovak program was valued

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[1] In practice, this task was nearly always delegated to enterprise management.

[2] Other ministries might intervene for companies with more than 3,000 employees or in cases calling for direct sales to private investors.

[3] Each political entity--the Czech Republic, the Slovak Republic, and the federal state--had a national property fund, the purpose of which was to hold shares of state enterprises after they were transformed into joint-stock companies and until the shares could be sold through voucher auctions or by other means.

[4] For example, if a company had share capital of 5 million korun, it would have 5,000 shares.

[5] This policy is in direct contrast to the Russian program, in which each voucher had a face value of 10,000 rubles.

at 1,000 points and had to be registered with the government.[6] Of the 11 million eligible adults, nearly 8.6 million participated.

2.2.3 The auction's participants

Two distinct groups participated in the auction--individuals and investment privatization funds (IPFs). The IPFs were closed-end investment funds organized as joint-stock companies and registered with the federal Ministry of Finance. Some funds were set up by private individuals and companies; others by banks. Prior to round 1, an initial round known as round 0 gave individuals the opportunity to hand over their vouchers to the IPFs. Citizens could use some or all of their vouchers to buy shares of IPFs, which in turn, bought shares in the privatized companies. Two-thirds of the participants assigned all of their vouchers to IPFs. Many others assigned one or more vouchers to an investment fund but retained at least one voucher for personal use. In all, almost 72 percent of investment points were invested by IPFs. As noted by Kotrba and Svejnar (1993), the willingness of so many citizens to sign over their points to IPFs probably reflected their desire to diversify portfolios and reduce risk.

The competition among these funds was intense, prompting some to offer guarantees of 10-, and even 15-fold, returns within a year after the issuance of shares. In effect, investors were granted a put option, with a strike price equal to 10 or 15 times the initial investment of 1,035 korun. The absence of a regulatory framework for investment funds rendered the government powerless to stop the funds from making such guarantees. Legislation to tighten the regulation of IPFs' activities was not passed until April 1992, months after most funds had been established. One important positive aspect of the funds' competitive behavior, however, was that it greatly stimulated public interest in the program, resulting in a participation rate roughly double what government officials had been expecting.

Although 439 IPFs were registered, the 14 largest, each of which had over 100 million points, accounted for nearly 77 percent of the points assigned to investment funds and 55 percent of all voucher points (Dlouhy and Mládek, 1994). The single largest fund, run by the Czech Savings Bank, accumulated more than 900 million points, or nearly 1 million voucher books, representing more than 10 percent of the total points available to all investors in the first wave.[7]

2.2.4. The bidding rounds and the timing of events

Auctions were organized into five bidding rounds, the first of which started in May 1992. The exact number of rounds was not known before the first round, and the conduct and termination of the process was left to the discretion of the federal Ministry of Finance

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[6] This requirement made it impossible for someone to bid more than his or her endowment of points, or to trade the points in secondary markets. Foreigners could obtain, but not register, voucher booklets and, therefore, could not participate in the auction.

[7] Nine of the top fourteen investment funds were run by banks, and two by insurance companies. A peculiar feature of the Czechoslovak voucher privatization scheme was the use of vouchers for privatization of major financial institutions that were at the same time active players in voucher privatization.

(Kotrba and Svejnar, 1993). An official announcement that round 5 would be the last was not made until after that round had been completed. Because it was widely known that all unused points would become void after the auction, the uncertainty resulting from the Ministry's discretionary powers exerted significant pressure on individuals and IPFs to bid early.

By the end of round 5, in December 1992, 93 percent of available shares had been sold. The remaining 7 percent were held for future sale.[8] Leftover points could not be used for the second wave. The first wave of voucher privatization officially ended in late spring 1993 with the distribution of shares to individuals and IPFs.[9] The timing of key events is summarized in Table 1.

2.2.5. The role of the auctioneer and the auction's rules

In the first round, all shares were priced identically, 100 points for every 3 shares, or 30 shares per booklet. Investors could use all 1,000 points to bid for 30 shares in a single company, 15 shares in two companies, 10 shares in three companies, etc. The starting price of 33.333 points per share was calculated from the total number of points, 8.6 billion, divided by the number of available shares, 299.4 million, which corresponded to 299.4 billion korun of share capital divided by the 1,000-korun nominal value per share, plus an overpricing factor of about 16 percent. In the subsequent rounds, prices were updated using complex rules that were unknown to the auction's participants.

The CPP processed the bidding information for each round and published the results, but the repricing task was performed by a special working group appointed by a deputy minister in the federal Ministry of Finance. This group (hereafter, "the auctioneer") submitted alternative price-updating schemes after each round to a pricing committee composed of the deputy minister and one representative from each republic's privatization ministry. This committee then made the final decision.

The allocation of the shares in each round worked according to the following principles. When shares were undersubscribed, all investors who bid for those shares would receive them at that price and any remaining shares would then be offered in the next bidding round. When shares were oversubscribed by less than 25 percent, all bids from individual investors were filled, with a *pro rata* reduction for the IPFs. In such cases, the company was said to be "fully subscribed" and thus would not be available in later rounds.[10] When shares were oversubscribed by more than 25 percent, none of the shares were sold. All points bid for those shares were then returned to investors, and the company went to the next round. The auctioneer had the right in any round to exclude

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[8] These shares could then be sold directly to investors, floated on a public stock exchange, or distributed in the second wave of voucher privatization. Indeed, 185 companies that participated in the first wave were also part of the second Czech Republic wave (Dlouhy and Mládek, 1994).

[9] The process lasted 21 months, which according to Dlouhy and Mládek (1994), was a year longer than initially expected.

[10] Technically, this rule held only if IPF demand did not have to be reduced by more than 20 percent. Otherwise, the shares were deemed oversubscribed and all points were returned to the bidders. In other words, the shares would be treated in the same manner as those that were oversubscribed by *more* than 25 percent.

companies that were highly undersubscribed or with a market-clearing price in excess of 1,000 points.[11]

2.2.6. The information set

The information set available to participants included (1) the unobservable private information held by certain individuals and IPFs, (2) the public information on the companies before the start of the auction, and (3) the public information conveyed by the bids and reported by the auctioneer. Data for our empirical analysis were prepared by the CPP and include all firms participating in the first wave of the voucher auctions. Data for each company were made public through a CPP publication that was widely available at newsstands and post offices around the country. The data included, for the period 1989 to 1991, sales, profits, number of employees, bank debts, total debts, and total assets, in addition to company names, addresses, descriptions of business activity, identification numbers, shares offered, and allocation of non-coupon shares.

The auctioneer published the results of the auction after each bidding round. For each company, information was made available on aggregate demand, the split in demand between individuals and IPFs, the number of shares remaining, and the price for the next round.

[11] The logic of this rule was that any price greater than 1,000 points would make it impossible for an individual investor to acquire a share. In practice, however, no companies were withdrawn from the auction for this reason.

3 Empirical evidence

3.1 A profile of the participating firms

The auction included 1,491 firms, 988 firms in the Czech Republic and 503 in the Slovak Republic. Descriptive statistics for all firms are shown in Table 2.[12] The accounting variables are defined in Appendix 1. The INS variable at the top of the table is the ratio of the number of shares in the voucher program to the total number of shares. The median number of shares exceeded 70,000, although a few companies had enough shares outstanding to pull the mean to 200,000, above the third quartile. Most participating firms were small in comparison with publicly traded firms in Western markets. The median company had only 380 employees in 1991, although the presence of several firms with thousands of employees resulted in a considerably higher mean value, 916 employees. Sales revenues for most firms were modest, with a median of 122.3 million korun, or less than US$5 million. The median Czech company was bigger than its Slovak counterpart, both in sales, 143.53 million korun versus 80.56 million korun, and total assets, 119.91 million korun versus 71.35 million korun. As measured by absolute levels, return on assets, and profit margin, Czech companies were also considerably more profitable than Slovak companies. A crude productivity measure, profits per employee in 1991, also shows that Czech companies achieved noticeably higher productivity.

Sales and profits for the median Czech firm grew over the period--at annual rates of 5.82 percent for sales and 3.20 percent for profits. Its Slovak counterpart experienced a decline in both variables, of –2.21 percent for sales and –16.60 percent for profits. Most companies in both republics reduced their work forces during this period, which indicates that firms undertook at least some modest restructuring efforts before privatization.

3.2 The auction results

The auction was designed to transfer 300 million shares to investors endowed with 8.6 billion points. This section presents data on the price, demand, supply of shares, and number of points used in each of the five rounds. Both the unconditional and conditional cross-sectional distributions of these variables are given. A small set of conditioning variables includes the subscription status, *i.e.*, whether a company was under- or oversubscribed; nationality, *i.e.*, Czech or Slovak; and investor type, *i.e.*, individual or IPF.

3.2.1. Prices

Two sets of prices are given: the price posted by the auctioneer after each round and the price paid by the auction's participants, or the "transaction" price. The latter was equal to the former only for the fully or undersubscribed stocks because points were returned to

[12] Although not presented here, the statistics were also segmented by republic, Czech and Slovak.

their owners when the stocks were oversubscribed by more than 25 percent. Summary statistics are given for both sets of prices in Table 3.

Starting from a uniform price of 33.33 points per share, the unconditional distribution of posted prices becomes highly skewed after the first round. Because the mean is pulled by a few highly priced stocks, the median quoted price appears to be a more appropriate measure of central tendency than the mean price. The median price displays a U-shaped pattern, that decreases after the first round to 14.29 points and reverts back to the initial price of 33.33 points in the last round; in contrast, the average price increases throughout the bidding rounds except in round 5. After the first round, a 40-fold difference between the cheapest stock, 10 points, and the most expensive, 400 points, is evident. The price range reaches nearly 1,000 points by the fourth round when the cheapest stock is priced at 1.17 points and the most expensive at 1,000 points. Prices take on a limited number of values, from a low of 20 after the first round to a high of 65 in the fourth, implying a large "tick" size (the difference between two adjacent ordered prices).[13]

The cross-sectional distribution of posted prices conditional on the subscription status is equal to the unconditional distribution of the prices paid by the auction's participants for the fully and undersubscribed stocks. Few differences are observed in the second round between the unconditional and conditional distributions, but in rounds 3 through 5, participants bid aggressively for low-price stocks, which suggests widespread bargain hunting. The median price of the oversubscribed stocks is 4.17, 6.25, and 11.11 points in rounds 3, 4, and 5, respectively. In contrast, the median price of the fully and undersubscribed stocks, which corresponds to the price paid by investors, was 33.33 points in the last three rounds. Except in the second round, the median transaction price is equal to the original 33.33 points.[14] Pooling the fully and undersubscribed stocks results in a loss of information, as panel C of Table 3 indicates. After round 1, the median prices of the fully subscribed stocks, by round, are 14.29, 16.67, 8.33, and 9.55 points, versus 14.29, 50.00, 40.00, and 33.33 for the undersubscribed stocks. Investors apparently started to bid aggressively for low-price stocks after the second round.[15]

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[13] Czech companies commanded higher prices than Slovak companies after the second round. After round 1, the median posted prices for Czech companies were 14.29, 25.00, 25.00, and 33.33 points versus 14.29, 20.00, 20.00, and 25.00 points for their Slovak counterparts. The highest price fetched by a Czech stock was 1,000 points, versus 800 points for a Slovak stock. The lowest price was similar for Czech and Slovak stocks.

[14] For fully and undersubscribed stocks, the average price paid by IPFs and individuals can be estimated by weighting the price by the respective number of shares bought. The resulting value-weighted average prices paid by IPFs were 49.81, 56.73, 37.77, and 36.29 points in rounds 2 through 5. In contrast, the weighted average prices paid by individuals were 44.23, 66.96, 57.58 and 51.33 points.

[15] In her empirical study of the Czech mass privatization, Shafik (1994) analyzes the convergence of the price to an equilibrium and, using standard econometric techniques, such as linear regression, the random-walk property of prices. She concludes that market information explains about 85 percent of the variation in prices by the final rounds and that prices increasingly behave like a random walk. Her analysis is based on the price *posted* by the auctioneer after each round. Use of the posted price has two major problems, however. First, that price is a *known deterministic non-linear* function of a limited number of variables, which makes using regressions pointless. Furthermore, as shown in the repricing functions that were published after the second round, prices were *not* based on any of the variables considered by Shafik. Second, the price posted by the auctioneer does not correspond to the price paid by the auction's participants. As shown in Table 3, major differences exist in the cross-sectional and time-series

3.2.2. Relative demand

The unconditional and conditional distributions of relative demand, defined here as the ratio of the number of shares bid for in a given round to the number of shares available, are reported in Table 4.

As shown in panel A, the unconditional distribution is highly skewed, especially in the first round. The mean is pulled by a few shares with high demand.[16] Also, about 400 companies had relative demand less than 17 percent in the first round. Because of the asymmetry of the distribution, the mean and the median differ substantially. The average relative demand is greater than 1.0 in the first three rounds and decreases monotonically from round 1 to round 5. The median is less than 1.0 in all rounds, with an inverse U-shape, increasing in the first three rounds and decreasing thereafter. Stocks were generally undersubscribed and became even more so in the later rounds. The minimum and maximum values for relative demand suggest that both deep over- and undersubscription persisted throughout the five rounds, but not necessarily for the same stocks.

The cross-sectional distributions of relative demand conditional on the subscription status are shown in panel B. A small number of stocks was fully subscribed in each round. By the end of the auction, 295 companies, about 20 percent of the total, had been fully subscribed. Throughout the auction, there were roughly twice as many undersubscribed than oversubscribed stocks. The number of oversubscribed stocks declined dramatically in the later rounds; in round 5, undersubscribed stocks outnumbered oversubscribed stocks by nearly 10 times. The median relative demand of the undersubscribed stocks is under 0.50, whereas that of the oversubscribed stocks is above 2.00. Little evidence suggests that the conditional medians converge toward 1.00 during the five bidding rounds.

Panel C contains the distribution conditional on investor type. Two results emerge. First, the participation of IPFs peaked in the second round and decreased thereafter. Conversely, individuals were less eager to bid in the first two rounds than in the later rounds. Second, the standard deviation of the individuals' relative demand is much higher than that of IPFs in every single round. The right tail of the distribution reveals the propensity of individuals to bid up certain stocks. The left tail shows the IPFs' lack of interest in many stocks. The first quartile is close to zero in most rounds for IPFs, unlike what is observed for individuals.

3.2.3. Points

In every round, the number of points consumed by investors was less than the number of points bid. The difference between the two variables is equal to the points returned to investors for bidding in oversubscribed stocks. The ratio of the number of points used to

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distributions of the posted and transaction prices in the second, third, and fourth rounds. As is standard in the financial economics literature, the transaction price should have been used to study the convergence to an equilibrium and the random-walk property.

[16] In one famous case, a typographical error resulted in an extra zero being added to the profits of a hotel. The relative demand for this stock at the end of the first round was 145.

points bid provides information about the clustering of bids among companies. The less clustered the bids, the greater the probability of undersubscription and the higher the ratio. Table 5 presents statistics on the aggregate number of points and the number of points conditional on investor type, individuals or IPFs.

In the first round, the auction's participants bid nearly 8 billion points, or 93 percent of their initial endowment. About 5.6 billion points were returned, giving back to investors 65 percent of their initial endowment before the second round. In the second round, investors bid 4.9 billion points, or 87 percent of the total remaining points, of which 3.4 billion points were used. The ratio of points used to points bid increases from 37.61 percent in the first round to 69.89 percent in the second. The participants' bids were more clustered in the first round than in the second, which suggests that participants reacted differently to the change in posted prices after the first round.

After the second round, participants were left with 2.20 billion points, slightly less than 26 percent of the initial endowment. They bid 1.99 billion points in the third round, about 90 percent of the total available, and used 1.02 billion points. The decrease in the ratio of points used to points bid, compared with the previous round, again suggests that bids were more highly clustered. This result is probably related to the bargain hunting documented previously. Only 1.18 billion points remained after round 3, 13.73 percent of the initial endowment. Participants bid 1.00 billion points in the fourth round, and used only half of them. Finally, in the last round, investors bid and used nearly all of their remaining points, 92 percent. Less than 2 percent of the initial endowment of points was left after the last round.

Participants bid 85 to 93 percent of their initial or remaining endowments in each of the five rounds, which suggests that they did not wait to accumulate information before bidding. IPFs bid more aggressively than individuals in the first two rounds. The ratios of the points bid to their respective endowments in the first two rounds are 95.61 percent and 91.22 percent for IPFs versus 83.74 percent and 77.58 percent for individuals. Furthermore, IPFs' bids in the first two rounds were less clustered than those of individuals, resulting in proportionately more points being returned to the latter. In other words, individuals were more likely to bid for companies that were oversubscribed. Consequently, individuals were left with 37.17 percent of their initial endowment after the first two rounds versus 21.11 percent for IPFs. Finally, although IPFs controlled 72 percent of all available points, IPFs and individuals had roughly the same number of points left over after the third round.[17]

3.2.4. The supply of shares

[17] In the first two rounds, Czech companies attracted 80 percent and 83 percent of the points bid, even though Czech shares represented just 70 percent of the total. The greater demand for Czech companies came primarily from IPFs. Consistent with the evidence on conditional relative demand, the ratio of points used to points bid is higher for Slovak stocks, which suggests that Czech companies were more likely to be oversubscribed than their Slovak counterparts. The percentage of total points bid for Slovak companies increased in the later rounds, whereas the ratio of points used to points bid declined.

The number of shares transferred to participants in a given round depended on both the number of points bid and the subscription status. No shares were transferred when stocks elicited no bids or when they were oversubscribed by more than 25 percent. The unconditional and conditional cross-sectional distributions are presented in Table 6.

Panel A gives the unconditional distribution of the number of shares left before and after each round. The distribution is highly skewed, with the mean pulled by a few companies having a large number of shares remaining, including one company with nearly 15 million shares. The median number of shares available before the first round was 71,301. After the first round, 90 million shares were transferred, reducing the median to 49,034 shares for the 1,443 remaining companies. Investors bought 75 million additional shares in the second round, further reducing the median to 30,122 for the 1,370 remaining stocks. More than half of the shares available in the auction had already been transferred by the end of the second round. The pace then slowed, as investors bought 33, 37, and 41 million shares in the final three rounds. After the last round, fewer than 22 million shares were left, slightly less than 7 percent of the initial total; the median number of shares remaining was 3,976. The number of shares transferred to investors is a U-shaped function, which peaks in the first round, bottoms out in the third, and increases slightly in the final two rounds.[18]

As shown in panel B, significant differences are evident in the distributions conditional on subscription status. For example, the median number of shares left over after the first round was nearly twice as high for undersubscribed stocks as for oversubscribed stocks, which indicates a preference for companies with relatively few shares outstanding. This preference was even stronger in round 2, but reversed in the third and subsequent rounds as participants turned to companies with many shares remaining. In the fourth round, oversubscribed stocks have a median number of shares four times higher than undersubscribed stocks. Also, the median number of shares remaining from the previous round is higher for fully subscribed stocks than for either the under- or oversubscribed group, which means that fully subscribed companies were relatively large.

The auction was an overwhelming success in terms of property transferred and points absorbed. Yet the empirical evidence reported in this section reveals intriguing results: (1) the large number of undersubscribed companies, especially in the later rounds, (2) the U-shaped pattern of the median posted price, (3) the inverse U-shaped pattern of the median relative demand, which remains below 1.0 throughout the auction, and (4) in the third round, bargain hunting and participants' new-found preferences for companies with a large number of shares remaining. A thorough understanding of these results requires an analysis of the price-setting mechanism.

4 The price-setting mechanism

[18] Although round 2 consumed the highest number of points, the greatest number of shares was sold in round 1; 90 million shares were sold for 3 billion points in round 1 versus 77 million shares for 3.4 billion points in round 2. The reason is that the average selling price increased from 33.33 points in round 1 to 42.81 points in the following round.

Before the first round, all companies were priced uniformly. After each round, the auctioneer updated prices for companies that were not fully subscribed. This section examines the information used by the auctioneer to update prices and the exact price-updating rules, which are shown to be complex, non-linear functions of the variables in the information set of investors. Appendix 3 describes the evolution of the price-updating rules during the five bidding rounds.

4.1 The auctioneer's objective function

The auctioneer's principal goal was the quick transfer of assets in a politically acceptable manner, which called for minimizing the number of points and shares left after the final round. Price discovery was a secondary motive. To achieve the auctioneer's principal goal, the price-updating rules were designed to *overprice* the shares systematically, although the degree of overpricing changed during the auction. This bias is in stark contrast to the underpricing normally observed for initial public offerings (IPOs), but comparisons between this auction and conventional IPOs can be misleading, partly because of the relative nature of asset valuation in the voucher program. Also, the auctioneer had a very different set of priorities from those of the typical IPO seller. The *worst* outcome for the auctioneer was an oversubscribed stock because, in that case, no shares were transferred and all points were returned to the participants.[19] As a result of first-round bidding, 90 million shares were sold to investors, nearly one-third of the total supply; 3 billion points were absorbed by those shares. However, 5 billion points were returned to investors. The auctioneer then manipulated the price, *i.e.*, overpriced, to decrease the probability of an oversubscription in the subsequent round. On the other hand, although overpricing was pervasive, the auctioneer occasionally *underpriced* to speed up the transfer of shares in the least demanded companies. The mispricing of securities can be seen as an efficient way to control the speed at which assets would be transferred and points absorbed, a conjecture that is supported by empirical evidence.

During two consecutive rounds, a stock could be undersubscribed twice, oversubscribed twice, under-, then oversubscribed, over-, then undersubscribed, over-, then fully subscribed, and finally under-, then fully subscribed. Panel A of Table 7 gives the probability of observing each of these six outcomes in each round and pooled for the rounds. The low probability of observing two consecutive oversubscriptions is striking. In contrast, the probability of two consecutive undersubscriptions is high in almost every round.[20] When pooled for all rounds, the probability of consecutive undersubscription is 45 percent, reaching 61 percent in the final two rounds. A simple explanation is that a large fraction of the assets had been transferred and the auctioneer was soaking up the points that, in the later rounds, were mostly in the hands of individuals.

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[19] Interestingly, one privatization official defined a successful bidder as an investor who received shares of an undersubscribed stock: "In fact, IPFs invested more successfully than individuals; *i.e.*, a larger ercent of individuals' points were returned because they allocated them to oversubscribed firms" (Kremar, 1992).

[20] A notable exception is after the second round, when the auctioneer under riced the least-demanded com anies to speed up the transfer of assets. Not surprisingly, these stocks were oversubscribed in the third round.

Panel B of Table 7 shows, for all stocks that were not fully subscribed by the end of the auction, the number of times a stock was undersubscribed during the five bidding rounds. Out of the 1,196 remaining companies, 71 were undersubscribed five times, and 693, four times. In contrast, no company was oversubscribed five times, and only 3 four times. Again, the systematic efforts of the auctioneer to overprice explains this striking asymmetry.

4.2 The price-updating rules

The auctioneer's price-updating rules were *deterministic* functions of a small number of variables and did not depend solely on relative demand in the previous round, as one would expect *a priori*. The price-updating rule in round j was based on four variables: (1) the subscription status in the previous round, *i.e.*, whether the stock was over- or undersubscribed, (2) the relative demand in the previous round, D_{j-1}, (3) the number of shares left, NS_{j-1}, and 4) price level in the previous round, P_{j-1}; that is,

$$R_j = F_j\,(1_{(D_{j-1} < 1.0)}, D_{j-1}, NS_{j-1}, P_{j-1}), \text{ with } j = 2,...,5, \qquad (1)$$

where R_j is the ratio of the posted prices in rounds j and j-1, $1_{(D_{j-1} < 1.0)}$ is a dummy variable that indicates the stock was undersubscribed in round j-1, and $F_j(.)$ is a function specific to round j. The shape of the function and comparative statics are discussed in the next section.

4.2.1. Subscription status and relative demand

The dummy variable for subscription status determines to a large extent the shape of the function and the variables to be included in the function.

- Controlling for the price P_{j-1}, the function F_j is linear with respect to relative demand D_{j-1}, for *oversubscribed* stocks:[21]

$$R_j = a_j + b_j D_{j-1}, \text{ with } j = 2,...,5. \qquad (2)$$

  where, in most cases, the slope b_j is equal to 1.0.
- Controlling for the price P_{j-1} and the number of shares left in the previous round, NS_{j-1}, the price-updating rule F_j is a non-linear function of relative demand in the previous round D_{j-1} for *undersubscribed* stocks:

[21] The function is not *stricto sensu* linear but has a kink, which results in a lower slope for the most highly oversubscribed stocks. The linear approximation is reasonable, however, given the limited number of highly oversubscribed stocks.

$$Rj = \sum_{l=1}^{l=m} b_{j,l}\, \mathbf{1}\, \varepsilon_{j,l} \le D_{j-1} < \varepsilon_{j,l+1} \text{ with } j = 2,\ldots,5. \qquad (3)$$

In Equation 3, F_j is a step function that takes on any of m different values, and $\mathbf{1}_{\{.\}}$ is a dummy variable equal to 1 when the relative demand in round j-1, D_{j-1}, takes on values in the interval $[_{j,l}, _{j,l+1}]$, and equal to zero otherwise.

An example is given in Figure 2, which displays the price-updating rule after round 1 (and before round 2). The different functional forms for over- and undersubscribed stocks allowed the auctioneer to control and minimize the risk of having an undersubscribed stock becoming oversubscribed in the subsequent round.

Contrary to conventional wisdom, the repricing factor R_j, defined as the ratio of the posted prices in rounds j and j-1, was not necessarily set higher than 1.0 for oversubscribed stocks and less than 1.0 for undersubscribed stocks. In other words, prices were not necessarily increased for oversubscribed stocks or decreased for undersubscribed stocks. Table 8 classifies the stocks into 4 groups:

- Group 1: Oversubscribed stocks in round j-1 whose prices were increased, $R_j >$ 1.00.
- Group 2: Undersubscribed stocks in round j-1 whose prices were decreased, $R_j <$ 1.00.
- Group 3: Oversubscribed stocks in round j-1 whose prices were decreased, $R_j \le$ 1.00.
- Group 4: Undersubscribed stocks in round j-1 whose prices were increased, R_j 3 1.00.

For each group, the median relative demand and the median repricing factor are also given. Two striking results emerge. First, few oversubscribed stocks had their prices decreased, whereas many undersubscribed stocks had their prices increased. The number of stocks in group 4 is marginally smaller than that of group 2 when pooled for all rounds, which means that almost half of the undersubscribed stocks had their prices increased. Second, the blatant overpricing of undersubscribed stocks is observed mostly in the final two rounds. The rationale for overpricing the undersubscribed stocks and for increasing the degree of overpricing in the later rounds was apparently to minimize the probability of oversubscription in the subsequent round and to absorb as many points as possible.

4.2.2. The number of shares outstanding

As Equation 1 showed, the price-updating rules also depended on two other variables, including the number of shares remaining, NS_{j-1}. This variable was of greatest importance to *undersubscribed* stocks, especially in the early rounds. After the first round, the median number of shares for the 1,443 remaining firms was 49,034, compared with 71,301 before the auction.

After round 2, the median number of shares left for all remaining firms was 30,122, but was 67,453 for undersubscribed companies. The auctioneer then began to reprice undersubscribed stocks using the rectangular functions, shown in Figure 3, regardless of whether the companies had a small or large number of shares remaining. The first group, referred to as group 2.5 in Appendix 3, comprises stocks with fewer than 11,000 shares left. The second group, group 2.6, comprises stocks with greater than 11,000 shares remaining that were undersubscribed in both rounds. For both groups, F_j is a rectangular function of both the relative demand in the previous round, D_{j-1}, and the number of shares left, NS_{j-1}. Figure 3 displays the function for group 2.5.[22]

$$R_j = \sum_{lj} \sum_{kj} b_{j,l_j,k_j} \mathbf{1}(\varepsilon_{j,l_j} \leq D_{j-1} < \varepsilon_{j,l_j+1}) \cap (\eta_{j,k_j} \leq NS_{j-1} < \eta_{j,k_j+1}), \text{ with } j = 2,\ldots,5 \quad (4)$$

where $\mathbf{1}_{\{.\}}$ is a dummy variable equal to 1 when the relative demand D_{j-1} takes a value in the interval $[\varepsilon_{j,l_j}, \varepsilon_{j,l_j+1}]$ *and* the number of shares left NS_{j-1} takes a value in the interval $[\eta_{j,k_j}, \eta_{j,k_j+1}]$ and equal to zero otherwise. For group 2.5, the higher D_{j-1} and the lower NS_{j-1}, the higher the repricing factor R_j, which as Figure 3 indicates, can be given any of four values between 1.00 and 4.00. In other words, although the stocks were undersubscribed in round 2, their prices were increased by as much as 300 percent. For group 2.6, the repricing factor R_j is given any of 8 values between 0.16 and 0.75.

The rationale for pricing the stocks in group 2.5 remained the same as before: the auctioneer deliberately overpriced to absorb as many points as possible. The rationale differed for the stocks in group 2.6. Because the stocks were undersubscribed in both rounds, the auctioneer was less concerned about absorbing points than transferring assets. The transfers were achieved by lowering prices, especially for the companies with many shares remaining.

4.2.3. The price level

The dependence of the price-updating rule F_j on price in the previous round, P_{j-1}, introduced a source of noise that makes price in round j, P_j, appear to be a random variable when, in fact, it was purely deterministic. An important problem faced by the auctioneer was that of the tick size, defined as the difference between two adjacent ordered prices. The relative demand in a given round could take on any value greater than or equal to zero and was almost continuous; the price could take on any value greater than zero and less than or equal to 1,000. In the first round, the relative demand took on 1,491 values, one for each company, with a low of 0.0037 and a high of 145.40. For the second round, however, the auctioneer posted only 20 different prices, ranging from 10 to 400 points. The tick size was an increasing function of the price, from a low of 1 point to a high of 100

[22] There was an exception, however, for the companies with greater than 950,000 shares remaining. For this group, the price-updating rule is a function only of the number of shares left, regardless of relative demand in the previous round. In such cases, the repricing factor R_j was 0.103.

points. In subsequent rounds, the auctioneer increased the number of values that a price could take on, thereby reducing the tick size. The number of values that prices could take on increased from 20 in round 2 to 40, 65, and 57 in rounds 3, 4, and 5, respectively.[23] A discrete, price-dependent tick introduced distortions, and the severity of those distortions was greatest when the size of the tick was relatively high, as in the early rounds.

Controlling for the number of shares left NS_{j-1}, the subscription status $\mathbf{1}_{\{D_{j-1}<1.0\}}$, and the relative demand D_{j-1}, the repricing factor R_j differed for stocks with different prices. This fact stemmed from the reluctance of the auctioneer to multiply the number of prices that stocks could take on in the subsequent round. For example, three oversubscribed stocks in the second round with similar numbers of shares remaining and relative demands equal to 1.31 were given repricing factors of, respectively, 1.00, 1.25, and 1.30 based on second-round prices of 33.33, 20.00, and 11.11. The high-price stock was thus underpriced by 30 percent relative to the low-price stock. Stated differently, relative demand had to be much higher for a high-price stock than for a low-price stock for the auctioneer to change the price by the same proportion.

4.3 A proxy for mispricing

We define a crude but simple proxy for mispricing, denoted by M_j, as the ratio of relative demand in round j, D_j, to the repricing factor P_{j+1}/P_j. A stock is assumed to be properly priced if M_j is 1.0. For example, a stock that was oversubscribed by 50 percent, and whose price was increased by 50 percent, is assumed to have been properly priced. Conversely, a company is assumed to be over- (under-) priced when the ratio M_j is less (higher) than 1.0. For example, a stock with relative demand of 0.30 in round j but whose price decreased by only 50 percent in round $j+1$ is assumed to have been overpriced.

The unconditional, cross-sectional distribution of the mispricing proxy M_j for each round is presented in panel A of Table 9. The mean and the median are less than 1, confirming that stocks were generally overpriced. The amount of overpricing decreased in round 3, when the auctioneer underpriced companies with many shares left, but increased sharply in the later rounds. Similar to the median relative demand, overpricing is an inverse U-shaped function. When one considers the distribution conditional on subscription status, however (panels B and C), a different picture emerges. Oversubscribed stocks tended to be underpriced, whereas undersubscribed stocks were overpriced. Also, the degree of mispricing was asymetric, being more important for under- than for oversubscribed stocks.

Knowing the auctioneer's objective function helps explain some of the results reported in the previous section. Relative demand increased as overpricing decreased. Furthermore, the underpricing of undersubscribed stocks in the third round explains the switch in investors' preferences from companies with few shares outstanding to those with many shares. Finally, the systematic overpricing explains why stocks were undersubscribed and why the number of undersubscribed stocks dramatically increased in

[23]Prices above 100 points were selected so as to be easily divisible into 1,000, partly because voucher booklets were divided into 100-point sections.

the later rounds. These results suggest that investors were rational, in that they bid aggressively for underpriced securities and generally avoided those that were overpriced.

5 Bidding strategies

Prior to the first round, individuals and IPFs had both private and public information on the companies' characteristics. After each new round, the information set expanded. The auctioneer revealed the relative demand in the previous round, the number of shares bought in the previous round (and thus the number of shares remaining for subsequent rounds), and the number of shares purchased by individuals versus IPFs and then posted a new price.[24] We next examine the participants' bidding strategies in light of this information set. Because all companies were priced identically at the start of the auction, we analyze round 1 separately from the others.

5.1 The participants' bids in the first round

In addressing the determinants of relative demand, we consider a set of accounting variables that includes the measures of profitability, growth, and risk defined in Appendix 1, a dummy variable for nationality (Czech or Slovak), industry dummy variables (see Appendix 2), and a variable that measures the percentage of a company's equity that was distributed through the voucher auction.

Because of the exploratory nature of our investigation, we used a stepwise selection technique for logistic and ordinary least squares (OLS) regressions. Specifically, we used the logistic regression based on iteratively reweighted least squares to find the "best" subset of variables. We then used OLS regressions to analyze the determinants of the relative demand of individuals and IPFs.[25]

The results are reported in Table 10. The subset of variables retained by the stepwise procedure for the logistic regressions correctly classifies the oversubscribed stocks in 87.3 percent of the cases. More importantly, despite their high number, only 12.5 percent of the undersubscribed stocks are misclassified. This result suggests that participants used the public information contained in the accounting variables before placing their bids. The subset of variables includes two industry dummies and seven other

[24] The value of private information and the optimal timing of the placement of bids--in particular who should bid in the first round--are not addressed here. It is not obvious that private information had the greatest value in the first round when all company shares were offered for the same price, as Shafik (1994) conjectures. Manipulative bids could have been placed to minimize the revelation of private information. The likelihood of manipulative bids was limited by the uncertainty regarding certain rules of the auction, however, which included (1) the auctioneer's price-updating rules (for example, a stock is undersubscribed and yet its price is increased), (2) the exact number of rounds, and (3) the subscription status (for example, a stock was declared fully subscribed even when the excess demand is higher than 25 percent, or a stock was or was not withdrawn from the auction when the demand was very small). The republican privatization ministries and the federal Ministry of Finance decided after each round on the price-updating rules for the subsequent round and which stocks would be available for that round. Such an uncertain environment was not favorable to the placement of manipulative bids.

[25] We also examined the industry preferences of investors, both individuals and IPFs. Results are available on request.

variables, all but one of which are accounting based. All regression coefficients have the expected signs. The two industry dummies--for sectors 3 and 8, light industry and banking and insurance--have positive signs, which is consistent with the evidence reported here. The relevant accounting variables are (1) two measures of profitability, ROA and level of profits, (2) sales growth for 1989 to 1991, (3) two measures of financial risk, total debt and total leverage, and (4) a measure of size, the number of employees, which enters with a negative sign.

One of the most significant variables in the regressions is the ratio of the number of shares available in the voucher auction to the total number of shares. The negative coefficient suggests that the lower the ratio, the higher the probability of the stock being oversubscribed. The shares not available in the auction included prior commitments to foreign and domestic investors; thus the ratio may have acted as a quality signal. The higher the number of shares bought by private investors, domestic or foreign, the lower the ratio and the higher the quality of the firm. There is evidence of participants free riding on these private investors by heavily demanding shares in those companies deemed attractive by the latter.

The OLS regressions were used to identify the determinants of the relative demand of individuals and IPFs. Table 10 shows that both groups bid up the prices of companies with few shares outstanding and, especially the IPFs, those companies with a low ratio of the number of shares available in the voucher program to the total number of shares. The IPFs were the primary users of the signal conveyed by the domestic and foreign prior commitments.

Other interesting differences are found in the demand of the individual and IPF investors. The R^2 of the regression is significantly higher for IPFs than for individuals (0.456 versus 0.300). Few accounting variables are retained by the stepwise procedure to explain the relative demand of individuals, which suggests that IPFs were better at exploiting the information in the accounting variables. IPFs focused on profitability, growth, and risk. Individuals were more concerned with size, as measured by total assets and by the number of shares available before the auction. Individuals bid up the prices of companies with high assets but few shares outstanding.

5.2 Bidding strategies after round 1

In attempting to identify the variables used by participants to bid on securities, we considered a logical starting point to be the three variables that entered the auctioneer's price-updating rules. The first variable is the aggregate relative demand in the previous round D_j, and relative demand segmented by bidder type, IND_j and IPF_j. The number of shares left after the previous round, NS_j, is the second variable, and price in the previous round, P_j, is the third.

The conditioning variables were ranked from low, group 1, to high, and 10 or 12 groups of equal size were formed. For each group, the median value of the conditioning variable, the median relative demand D_{j+1}, in the aggregate and split into types, IND_{j+1} and

IPF_{j+1}, in the subsequent round, are reported. A non-parametric statistic was used to test the equality of the location parameter across groups.

5.2.1. The relative demand conditional on past relative demand

To test the possibility that investors bid more or less aggressively for companies whose prices were bid up or down in the previous round, we formed groups according to relative demand and subscription status. The relative demand in round j was split into 12 groups. The first (last) 6 groups of equal size include under- (over-) subscribed stocks with relative demand ordered from low (group 1) to high (group 12). The results are reported in Table 11.

Two results stand out. Relative demand is a monotonically decreasing function of relative demand in the previous round only for round 3. This fact stems from the decrease in the posted price of companies with many shares outstanding that had received little interest in the earlier rounds, which triggered the bargain hunting described earlier. In all other rounds, a strange pattern emerges. The median relative demand in round j+1 is a U-shaped function of the median relative demand in round j. The peak coincides with the least undersubscribed stocks in the previous round. Investors bid more aggressively for moderately undersubscribed stocks, perhaps because investors considered the price of these stocks to be closest to their equilibrium values and the companies thus to have the highest probability of being fully subscribed in the subsequent round.

Another important issue is that of mimicking bids. Less sophisticated investors, (here, individuals), can be expected to mimic the bids of more informed and experienced investors (here, the IPFs). To test for such behavior, we studied the relative demand in round j+1 for each of the two investor types conditional on both (1) its own past relative demand and (2) the past relative demand of the other investor group. Each variable was split into 10 groups of equal size from low (group 1) to high (group 10), or 100 groups in all. The number of observations and the median subsequent relative demand are reported for each group for round 2 in Table 12.[26]

The last column (row) in Table 12 gives the median relative demand of individuals conditional on their (IPFs') relative demand in the previous round. Confirming earlier evidence, a U-shaped pattern is observed. Also, the relative demand of individuals displays little sensitivity to either of the two conditioning variables. If the last row and column of the matrix are excluded, the evidence on the mimicking-bid hypothesis is mixed. The relative demand of individuals is low when the demand of IPFs was low in the previous round. Some evidence exists, however, that the relative demand of individuals was low when the demand of IPFs was high. Individuals apparently did not interpret the signal conveyed by the IPFs' bids uniformly across stocks. The results suggest that any signals sent by the bidding behavior of IPFs may have influenced individuals' bidding strategies for low-value but not high-value companies.

5.2.2. The relative demand conditional on the number of shares left

[26] Results for the other rounds are available on request.

We found evidence of strong demand, especially from individuals, for companies with few shares available in the first round. The auctioneer responded by disproportionately increasing the price of those companies. The results, reported in Table 13, with group 1 (10) containing companies with few (many) shares outstanding, confirm that individuals continued to bid aggressively for companies with few shares remaining in round 2 despite the overpricing. No such effect is observed for IPFs. Participants' preferences changed in round 3, however. IPFs and, to a lesser extent, individuals went after companies with many shares outstanding, which apparently stemmed from the deliberate underpricing of those stocks by the auctioneer. The median relative demand of IPFs monotonically increases with the number of shares, especially in the later rounds. No such pattern is observed for individuals, which suggests that IPFs were better able to detect mispriced securities.

5.2.3. The relative demand conditional on price

Table 14 reports on individual and IPF relative demand conditional on price. For round 2, 20 groups were formed corresponding to each of the 20 different prices posted by the auctioneer at the beginning of the round. (For subsequent rounds, we report only those groups with a price of 200 points or less.) One striking result that emerges from this table is the low relative demand among both IPFs and individuals for high-price stocks in all rounds. This result is not surprising for individuals, who most likely tried to maximize the number of shares they could acquire with their 1,000-point endowment. The result is more difficult to explain for IPFs, unless high-price stocks were systematically overpriced. Also, an almost monotonic inverse relationship exists between relative demand and price in the later rounds. Investors bid more aggressively for the lowest price stocks, which in turn, corresponded to the companies with many shares outstanding. In the second and third rounds, the relationship between price and relative demand is U-shaped for both IPFs and individuals. Investors preferred low-price stocks but not the lowest price stocks.[27]

5.3 The rationality of participants' bidding strategies

Oversubscribed stocks tended to be slightly underpriced, and undersubscribed stocks severely overpriced. Furthermore, the prices of many undersubscribed stocks were actually increased, especially in the later rounds, and conversely, prices were reduced for a few oversubscribed stocks. In this section, we report the bidding strategies of individuals and IPFs in the presence of mispriced securities. The purposes are to determine whether or not investors bid up (down) the price of under- (over-) priced stocks and to discover any evidence of learning during the rounds.

Participants' bidding strategies were studied by relating relative demand D_{j+1} to the proxy for mispricing M_j, defined as the ratio of relative demand in round j to the repricing

[27] An interesting example is provided by the subset of stocks priced at 150 points after the first round whose price was arbitrarily decreased to 100 points or increased to 200 points to allow price to be easily divisible into 1,000. The auction's participants immediately spotted the inefficiency and bid aggressively for the 100-point companies.

factor R_j. Both variables were part of the public information set before bidding in round j+1. Unconditional tests were performed in addition to tests conditional on the subscription status and on a dummy variable that can take on any one of four values depending on whether the stock was over- (under-) subscribed in round j and the price was subsequently increased or decreased.

Table 15 presents, for each round, the median relative demand D_j, the repricing factor R_j, the mispricing factor M_j, and relative demand D_{j+1}, both pooled across participants and segmented for individuals and institutions, IND_{j+1} and IPF_{j+1}. Panel A shows the unconditional median, and panel B, the median conditional on subscription status. The results show that (1) relative demand was highest in round 3, when a large group of stocks was underpriced, (2) except in round 3, relative demand was higher for stocks that had been oversubscribed in the previous round, and (3) IPFs had a clear preference for oversubscribed stocks, which suggests superior ability in detecting underpriced securities.

More revealing tests were performed by sorting the mispricing measure M_j into deciles. Values below (above) 1.0 are evidence of overpricing (underpricing). Table 16 gives the median value for M_j, the subsequent median aggregate relative demand in round j+1, D_{j+1}, and demand segmented for individuals and institutions, IND_{j+1} and IPF_{j+1}. We used a non-parametric median score statistic to test whether the distribution of relative demand has the same location parameter across groups. The null hypothesis of the equality of median relative demand in round j + 1 across groups is strongly rejected both for the IPFs and individuals. Evidence is clear that the median relative demand increases with M_j but in a non-monotonic fashion. The superior ability of IPFs to detect mispriced securities is confirmed here; they hardly bid at all for the most overpriced stocks but bid aggressively for those that were underpriced. In the final two rounds, IPFs used their remaining endowment of points, less than 6 percent of the original amount, to buy deeply underpriced stocks. As for individuals, demand was usually lowest for the most overpriced stocks, but the association between the median mispricing measure M_j and median relative demand is much weaker. Furthermore, there is little evidence of learning by individuals during the rounds.

Another way to study the rationality of investors is to determine the extent to which the mispricing measure M_j can predict subscription status, *i.e.*, whether a stock will be under- or oversubscribed in the subsequent round. To examine this issue, we used a logistic regression with the following explanatory variables: the mispricing measure M_j, the number of shares left before the round NS_j, and the price level in round j, P_j. The last two variables were included to determine any investor preferences for stocks with few or many shares outstanding and with a low or high price, after controlling for mispricing.

The regression equation is

$$1_{D_{j+1}>1.0} = \sum_{i=1}^{i=4} \alpha_{i,j} + \sum_{i=1}^{i=4} \beta_{i,j} M_j + \sum_{i=1}^{i=4} \gamma_{i,j} P_j + \sum_{i=1}^{i=4} \delta_{i,j} NS_j + \varepsilon_j, \text{ with } j = 2,\ldots,5, \quad (5)$$

where the four intercept and slope dummies correspond to the four groups defined in section 4.2.1.[28] The dependent variable is the probability that the stock is oversubscribed in the next round. The results are reported in Table 17.[29]

As reported in section 5.1, the best model for predicting which stocks would be oversubscribed in the first round correctly classified 87.3 percent of the oversubscribed stocks and misclassified 12.5 percent of the undersubscribed stocks. For the third round, however, a model based only on the three right-side variables in Equation 5 properly classified 93 percent of the oversubscribed stocks; only 6.8 percent of the undersubscribed stocks were incorrectly classified. The percentage of correctly classified companies deteriorates in the final two rounds, which may reflect the increased participation of noise traders (*i.e.*, individuals).

As predicted, the coefficients $_{i,j}$ associated with the mispricing have positive signs. Unlike $_{2,j}$, the coefficient $_{1,j}$, is not always statistically significant, which is not surprising given the asymmetry between the deep overpricing of undersubscribed stocks and the modest underpricing of oversubscribed stocks. The regression coefficient $_{4,j}$ is statistically significant for the group of undersubscribed stocks whose prices were increased. The coefficients associated with the price level, $_{i,j}$, are generally insignificant, especially for the oversubscribed stocks. The price level in round j becomes irrelevant for predicting which stocks will be oversubscribed, except for those in group 4. The regression coefficient $_{4,j}$ is negative, which means that investors, mostly individuals, bought overpriced stocks but principally those with relatively low prices. Finally, evidence that the number of shares left still mattered is weak. Most $_{i,j}$ coefficients are negative, which suggests a preference for stocks with few shares outstanding; the exception is $_{1,j}$ after the second round, but the coefficient is statistically significant in only a few cases.

The results obtained from the logistic regression suggest that the mispricing measure M_j is a good predictor of subscription status in the subsequent round. Investors, especially IPFs, bid up (down) the price of under- (over-) priced stocks. Other variables, such as price level and the number of shares outstanding, apparently mattered little. In summary, the empirical evidence suggests that demand was driven by fundamentals in the first round and by the search for underpriced or the least overpriced securities in subsequent rounds and that IPFs were more rational investors than individuals.

6 The information content of prices

As Milgrom and Weber (1982) argue, through the bids of the participants, auctions reveal useful information about the underlying value of firms. This information can facilitate the emergence of financial markets as future investors become informed about the value of newly privatized firms. In this section, we examine the information content of prices to

[28] The coefficients of the third group could not always be estimated because of the small sample size.
[29] Similar OLS regressions were performed in which the dependent variable was the relative demand of individuals and IPFs. Results are available on request. Logistic regressions could not be run for the segmented demand because a stock's under- or oversubscribed status could be determined only from aggregate demand.

determine whether they provide reliable signals about the (relative) values of companies. As discussed earlier, the auctioneer deliberately mispriced securities to absorb points and speed up the transfer of assets. The price-updating rules adopted by the auctioneer thus depended on more than simply relative demand and included such variables as the number of shares outstanding and tick size. Because investors generally responded rationally to the auctioneer's deliberate mispricing, the practical effect of the auctioneer's repricing policy was to inject noise. Furthermore, because the auctioneer systematically overpriced securities, mispricing accumulated during the five bidding rounds. This bias would not be a concern in revealing value if the mispricing was uniform across securities. In this auction, however, mispricing was not uniform and, moreover, changed in the course of the auction because the price-updating rules were modified after each round.

6.1 The "surviving" stocks

In examining the information content of the price in round 5, we first consider the relationship between the price in round 5 and relative demand in round 1, because only in that round did demand appear to be driven primarily by measures of fundamental value. In subsequent rounds, demand was driven mostly by the search for mispriced securities. The price in the final round should be correlated with relative demand in the first round unless price is buried in the noise introduced by the auctioneer.

Table 18 shows the number of companies and the median price in round 5 for each of 100 groups formed according to relative demand in round 1 and the number of shares outstanding before round 1. Relative demand was segmented into over- and undersubscribed stocks, with five groups of equal size created for both groups. The same procedure was followed to generate 10 groups of equal size, formed according to the number of shares outstanding before round 1. The last column of the matrix displays the median price conditional on subscription status and relative demand. The median price increases with relative demand but not monotonically. The lowest (highest) median price is 5.88 (175.00) points. The price of the least-undersubscribed stock is higher than that of the least oversubscribed stock, 50.00 points versus 40.00. This result is not surprising given the different price-updating rules used for over- and undersubscribed stocks.

The last row of the matrix gives the median price conditional on the number of shares outstanding. It shows that price was a function of this variable. The median price of companies with the lowest number of shares outstanding was 100 points, or four times the median price of companies with the highest number of shares outstanding. This result might be expected if the demand for the former was higher than the demand for the latter, as documented for the first round. This demand pattern was not the case, however. When we control for relative demand, a sizable difference emerges between the median price of stocks with a high and a low number of shares outstanding. This effect prevails for all groups except the two with the highest relative demand.

Another way to gauge the amount of noise in prices introduced by the auctioneer's price-updating rules is to examine the relationship between prices in the final round and subscription status during the five bidding rounds. The number of times a stock was

undersubscribed or the ordering of under- and oversubscriptions in the five rounds should be irrelevant for pricing if the auctioneer was driven solely by the price-discovery motive. Table 19 displays for each subscription path the number of companies, the median relative demand in round 1, the median number of shares before round 1, the median posted price in round 5, and the median number of shares left after round 5 in absolute and relative terms for the 1,236 remaining firms. The paths are ordered--the top (bottom) half representing over- (under-) subscribed stocks in the first round.

A few paths dominate in terms of sample size; paths UOUUU and OUUUU, combined, comprise one-third of all companies. As documented earlier, alternating sequences of under- followed by oversubscriptions, such as OUOUO or UOUOU, are rare. Table 19 shows that a key determinant of the median price in round 5 was whether the stock was over- or undersubscribed in the first round. The median price was often above (below) the unconditional price of 33.33 points for over- (under-) subscribed stocks. There were exceptions, however; 68 oversubscribed stocks in the first round finished with a median price in round 5 below 33.33 points. Only 14 undersubscribed stocks in the first round finished with a price greater than 33.33 points.

The finding that the price in round 5 is correlated with the subscription status in the first round is reassuring. It confirms earlier evidence that prices reflected the companies' fundamentals. It is surprising, however, to find that the paths lead to different median prices. If the sample size was large enough for any single path, one would expect, given the law of large numbers, that different paths would lead to the same price; *i.e.*, price should reflect stock fundamentals and not the subscription path. Similarly, how many times a stock was undersubscribed in the five rounds should not matter. The evidence presented in Table 20, however, shows that, for the two most frequent paths, three and four undersubscriptions, the median price in round 5 was 14.29 and 33.33 points, respectively. Clearly, both the subscription path and the number of undersubscriptions affected price.

6.2 The fully subscribed stocks

The previous section showed that stock price in round 5 was a function of subscription status. Our analysis thus far has focused on under- and oversubscribed stocks, but another group of stocks, those that were fully subscribed, represent one-fifth of the total. Political pressure to have a certain number of stocks fully subscribed in each round may explain this result. The question of why these stocks were fully subscribed is of less interest in this study, however, than whether they were systematically mispriced. As Table 3 documented, the median price of fully-subscribed stocks was lower in each round than either the under- or oversubscribed stocks in that round, which suggests that such stocks were underpriced.

To test this hypothesis, we computed, in each round, the difference between the price at which stocks were fully subscribed and the median price in round 5 of a control group created by sorting the stocks into 10 groups of equal size according to the relative demand in round 1. This procedure allowed us to control for the relative demand in round 1 and

hence for the stock fundamentals. The price difference should be equal to zero. The unconditional cross-sectional distribution of the price difference conditional on the round number is reported in Table 21. The unconditional and conditional medians are negative, which suggests that the fully subscribed stocks were underpriced. Further, evidence exists that, as expected, the underpricing decreased during the rounds.

7 Conclusions

The artificial primary market created by the Czechoslovak Ministry of Finance for the mass privatization of nearly 1,500 companies was a unique experiment in the history of financial markets. The principal goal of the auction was quickly to transfer billions of dollars in assets to Czechoslovak citizens in a politically acceptable manner. In their zeal to achieve this goal, auction officials purposefully injected noise into the bidding process and thus reduced the usefulness of the auction as a mechanism for revealing value. The cause was not the design of the auction *per se* but the price-updating rules used by the auctioneer, which consistently mispriced securities to absorb points and speed up the transfer of assets to private investors. Political expediency simply took precedence over price discovery. Prices did reflect fundamental values--such as profits, growth, and risk--but this information had been largely impounded by the end of the first round. Afterwards, accumulating non-uniform pricing errors created noise. The results of this study suggest that designers of politically motivated auctions face a tradeoff between socially acceptable outcomes and efficient price discovery.

As data become available, the recently completed second wave of voucher privatization in the Czech Republic will allow for out-of-sample verification of the results reported in this paper. Also, the usefulness of the auction as a mechanism to reveal value awaits a more definitive test that would compare, cross-sectionally, auction prices and market prices for the stocks that now trade on public stock exchanges. This issue, as well as others--such as the optimal timing of bids for IPFs and individuals and the existence of manipulative bids--are left to future research.

Appendix 1
Definitions of accounting variables

1. Miscellaneous

- Sales = sales for the year 1991
- Profits = profits for the year 1991
- Bdebt = bank debt for the year 1991
- Employ = employee numbers in 1991
- Tdebt = total debt
- Assets
- INS = ratio of the number of shares in the voucher program to the total number of shares outstanding

2. Leverage measures

- Lev1 = Bdebt/Tdebt
- Lev2 = Bdebt/Assets
- Lev3 = Tdebt/Assets

3. Profitability measures

- ROA = Profits/Assets
- Margin = Profits/Sales
- Produc = Profits/Employ

4. Growth measures

- Gsales = mean of sales growth in 1990 and 1991
- Gprofits = mean of profit growth in 1990 and 1991
- Gbdebt = mean of bank debt growth in 1990 and 1991
- Gemploy = mean of employee number growth in 1990 and 1991

5. Risk measures

- Risk1 = standard deviation of margin during the years 1989-91
- Risk2 = standard deviation of productivity during the years 1989-91
- Risk3 = standard deviation of return on assets

Appendix 2

Definitions of industry codes: code, industry, and number of companies in the industry (in parentheses)

- 00 Other and nonspecified (1)
- 11 Agriculture (61)
- 12 Forestry (2)
- 13 Water supply (6)
-
- 21 Fuel industry (15)
- 22 Production of electric power (17)
- 23 Iron and steel industries (11)
- 24 Non-ferrous industries (4)
- 25 Chemical and rubber industry (27)
- 26 Engineering (234)
- 27 Electrotechnical industry (51)
- 28 Building materials industry (61)
- 29 Woodworking industry (51)
-
- 30 Metalworking industry (21)
- 31 Pulp and paper industry (14)
- 32 Glass, china and stoneware industry (18)
- 33 Textile industry (42)
- 34 Clothing industry (2)
- 35 Leather, boot, shoe and fur industry (7)
- 36 Printing industry (20)
- 37 Food industry (148)
- 38 Cooling and tobacco industries (8)
- 39 Other industrial activities (8)
-
- 41 Building and civil engineering (224)
- 43 Geological activity (30)
- 45 Design activity (86)
-
- 51 Transport (39)
- 53 Communication (4)
-

- 61 Domestic trade (60)
- 62 Foreign trade (34)
- 63 Supply and sales of goods (4)
- 64 Supply of agricultural goods (43)
- 66 Publishing activities (5)
- 69 Other trade activities (5)
-
- 71 R&D in agriculture and forestry (0)
- 72 R&D in basic production (25)
- 73 R&D in consumer and food industries (7)
- 74 R&D in construction (7)
- 75 R&D in transport and communication (0)
- 76 R&D in commercial activities (2)
- 77 Fundamental science research (2)
- 78 Research and science services (2)
- 79 Services in R&D (0)
-
- 81 Housing (2)
- 82 Hotel industry (4)
- 83 Recreational services (7)
- 84 Public utilities (9)
- 85 Education (0)
- 86 Cultural services (4)
- 87 Medical and other health services (25)
- 88 Social care (0)
-
- 91 Other services (29)
- 92 Banking (6)
- 93 Insurance (1)
- 95 Public administration, courts (1)
- 96 Security and national defense (5)
- 97 Social organizations activity (0)

Appendix 3
Evolution of the price-updating rules

The contribution, or weight, of each of the four variables in the price-updating rule as well as the shape of the function F_j changed from one round to the next. The most salient features of this process are summarized here.

- After the *first* round, the auctioneer used (see Figure 2):
  - for oversubscribed stocks, a linear pricing rule with a slope b_1 equal to 1 for stocks with a relative demand lower than 10 and, otherwise, a lower slope;
  - for undersubscribed stocks, a step function. The repricing factor R_j was 0.43 for stocks with relative demand between 0.20 and 0.67. It bottomed out at 0.30 for approximately 400 stocks. This particular group had a relative demand under 0.20 in the first round and included the stocks with the highest median number of shares remaining.

  These rules did not apply to undersubscribed stocks with few shares left. Instead, their prices were increased. Summary statistics on the sample size, median relative demand, and median number of shares remaining before and after round 1 are given in Table 22 for each of the 20 repricing factors.
- After the *second* round, the auctioneer segmented the companies into six groups. The characteristics of each group are presented in Table 23.
  - Group 2.1 contains the 82 stocks that were oversubscribed in both rounds. The auctioneer used a linear pricing rule with a slope b_2 equal to 1.
  - Group 2.2 contains the 431 stocks undersubscribed in the first round but oversubscribed in the second. The same linear pricing rule was used: a slope equal to 1.0 (0.5) for stocks with a relative demand less (greater) than 3.0.
  - Group 2.3 includes the 73 stocks oversubscribed in the first round with a relative demand exceeding 3 but undersubscribed in the second. The number of shares remaining for each of these stocks was greater than 11,000. A linear pricing rule with a slope of zero was used. In other words, the price was unchanged.
  - Group 2.4 includes the 127 stocks oversubscribed in the first round but with a relative demand less than 3 and undersubscribed in the second. The number of shares left exceeded 11,000 in all cases. Price was decreased in accordance with a step function that took on any one of seven values. The lowest (highest) repricing factor for this group was 0.30 (0.75).
  - Group 2.5 is defined as the "small leftovers" group, *i.e.*, stocks that were under- or oversubscribed in the first round but undersubscribed in the second and having fewer than 11,000 remaining shares. For this group of 248 stocks, the price was increased according to the rectangular function described

previously. The repricing function took on any of four values, up to a maximum of 4. See Figure 3.

- Group 2.6 includes the 482 stocks undersubscribed in rounds 1 and 2. They were repriced according to the rectangular function with any one of eight values ranging from 0.103 to 0.750.

The overpricing of the 321 stocks in groups 2.3 and 2.5 is particularly obvious. These stocks were undersubscribed, but their prices were unchanged or increased. For the undersubscribed stocks in both rounds, group 2.6, the auctioneer was forced to lower the price after failing to do so after the first round. For this group, one trading round was wasted because of the overpricing strategy. The substantial decrease in price was responsible for the increase in the unconditional median relative demand after round 2, which peaked at 0.769.

- After *round 3*, the price-updating rules were simplified. Except for a small number of companies, the function F_4 is linear with either a slope of zero or 1. Prices were unchanged for 707 of the remaining 1,370 companies. The repricing factor R_4 was unchanged for, respectively 46, 333, 69, and 194 companies out of the 49, 391, 127, and 248 surviving companies in the previously formed groups 2.1, 2.2, 2.4, and 2.5 and increased for the other companies in those groups even though they were undersubscribed in round 3. Two groups stand out. Group 2.3 contains companies that were undersubscribed in the second round and whose prices were unchanged. Not surprisingly, they were deeply undersubscribed in round 3, forcing the auctioneer to lower the prices. The prices were lowered for the 41 most undersubscribed stocks of the 73 remaining in that group. Group 2.6 contains the stocks that were undersubscribed in the first two rounds and whose prices were significantly lowered after round 2. These companies were highly oversubscribed in round 3. Their prices were increased through use of a linear pricing rule with a slope of 1 except for the most heavily oversubscribed stocks (relative demand of 10 or greater).
- After *round 4*, notwithstanding the tick size and the price distortions it introduced, the price-setting rule was similar for all remaining stocks. Although most companies were undersubscribed in round 4, in 866 cases out of 1,317 the auctioneer applied the same linear pricing rule, with a constant $a_5 = 0.50$ and a slope $b_5 = 1.0$. A company with relative demand equal to 1.0 had its price increased by 50 percent. The companies were overpriced even more than in the previous round. The systematic overpricing of stocks in the last two rounds explains the drop in the unconditional median relative demand after round 3 reported in Table 3, which decreases from a peak of 0.769 in round 2 to 0.698 and 0.489 in the final two rounds.

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Figure 1

Approval Process for Large-Scale Privatization in Czechoslovakia

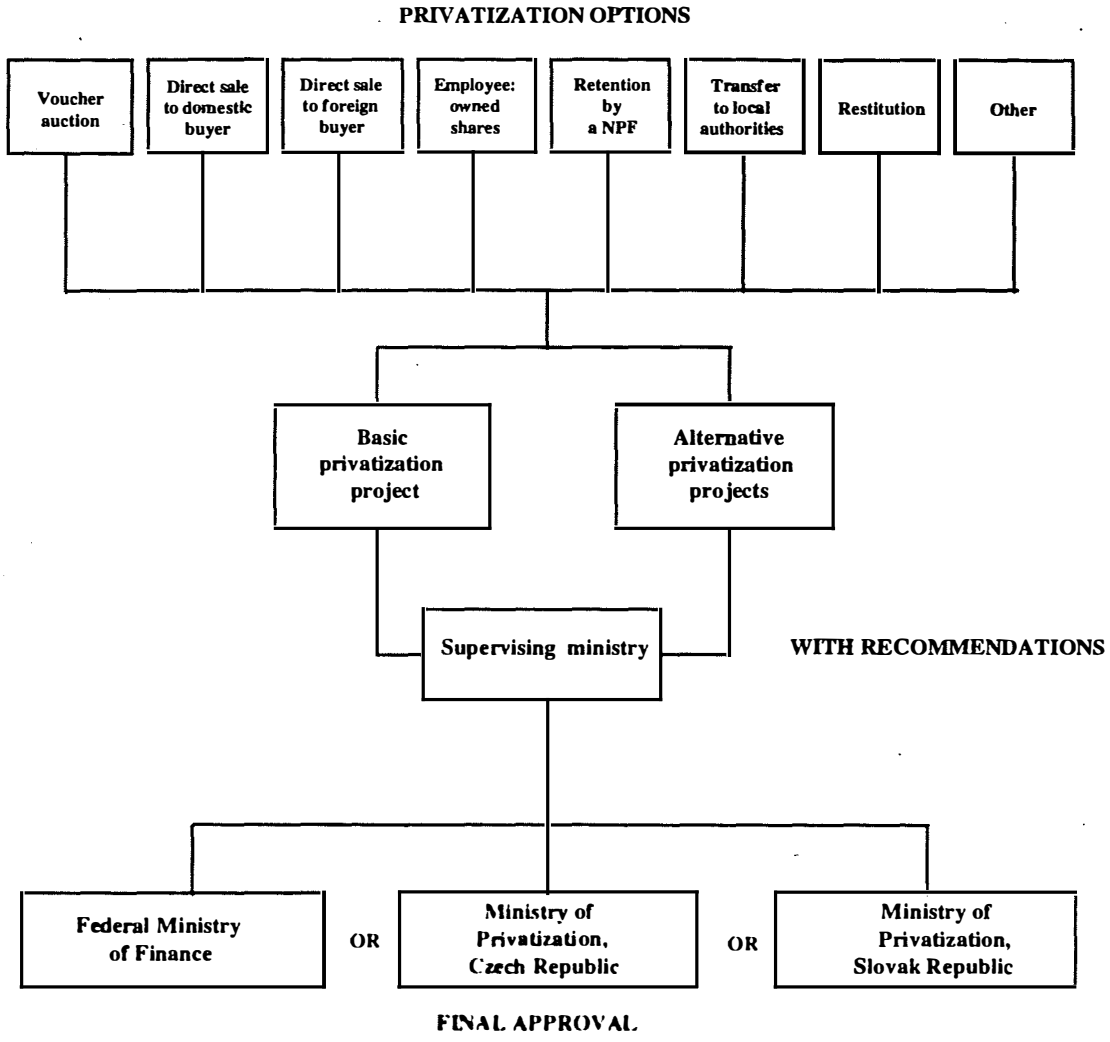
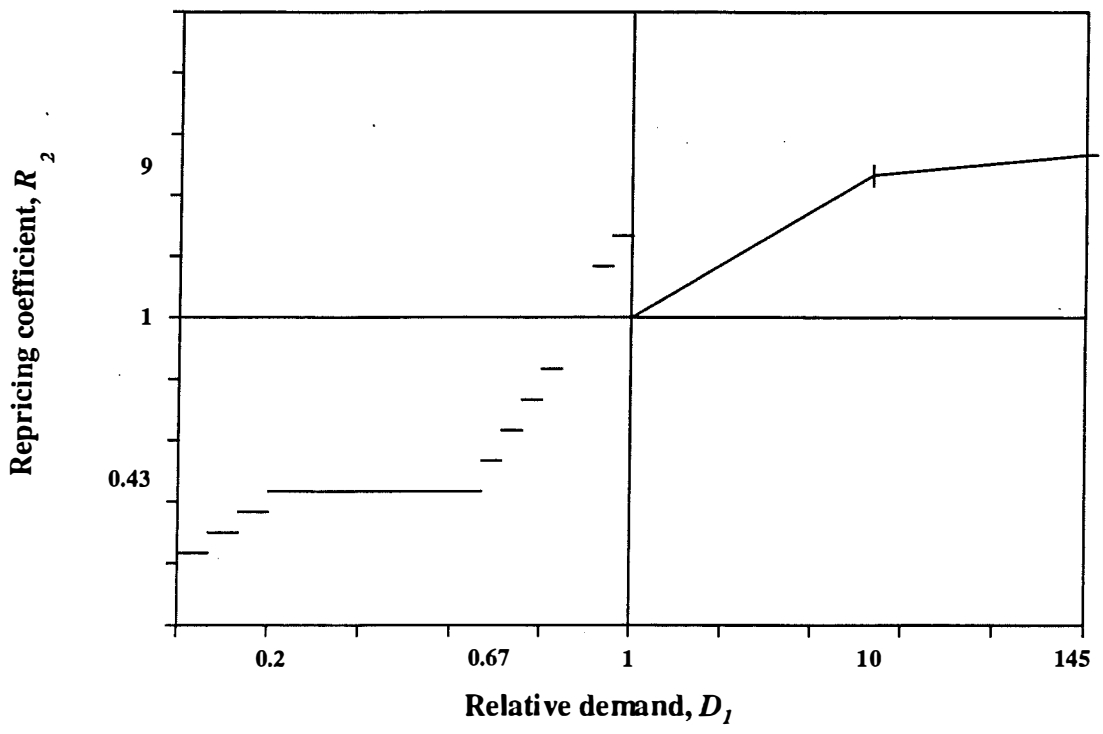
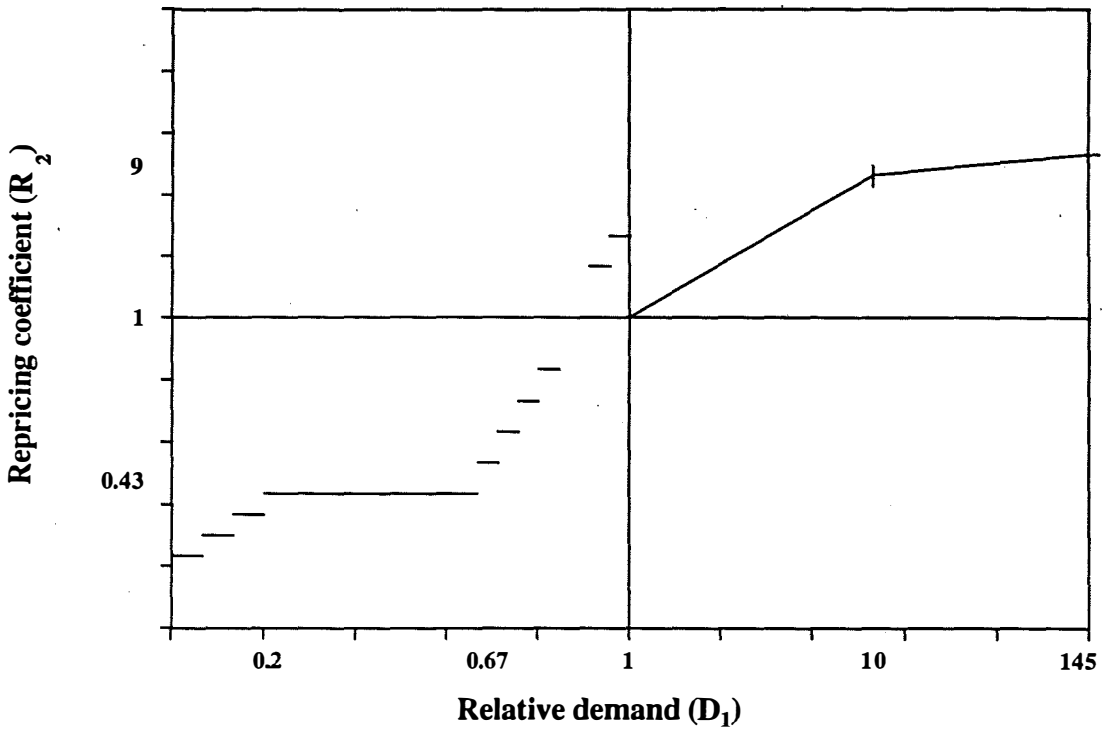


Figure 2
Repricing function after the first round for all remaining companies



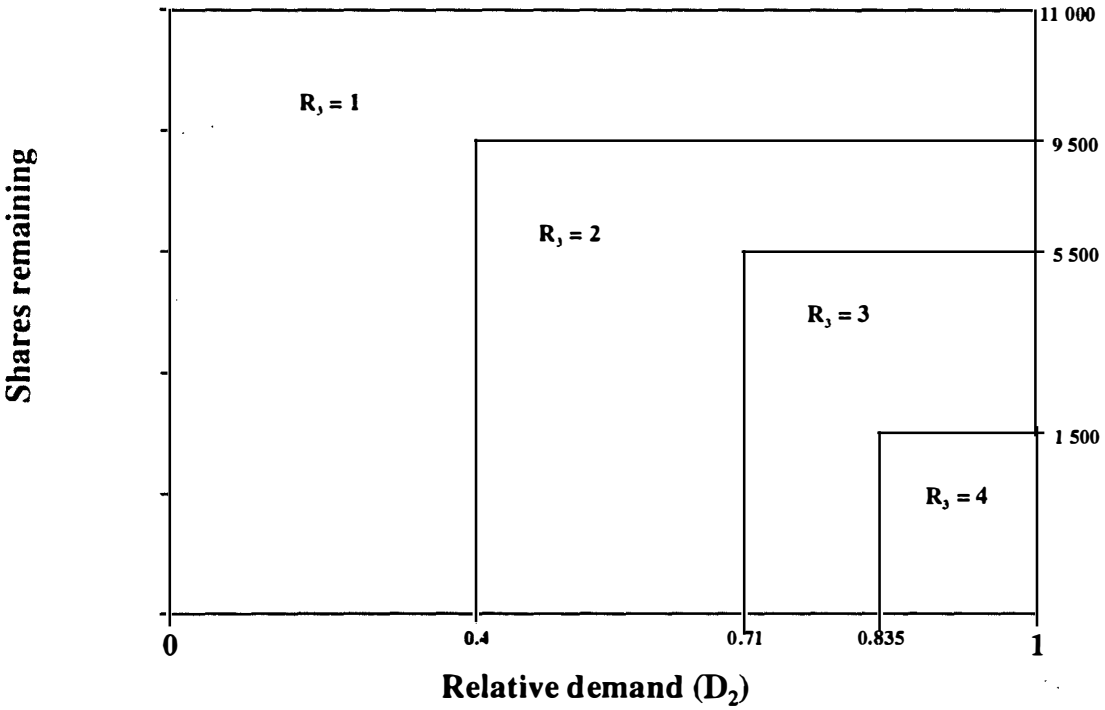
Note: Adapted from Krcmar (1992).
The exact repricing factors are given in Table 22

Figure 2A
Repricing function after the first round for all remaining companies



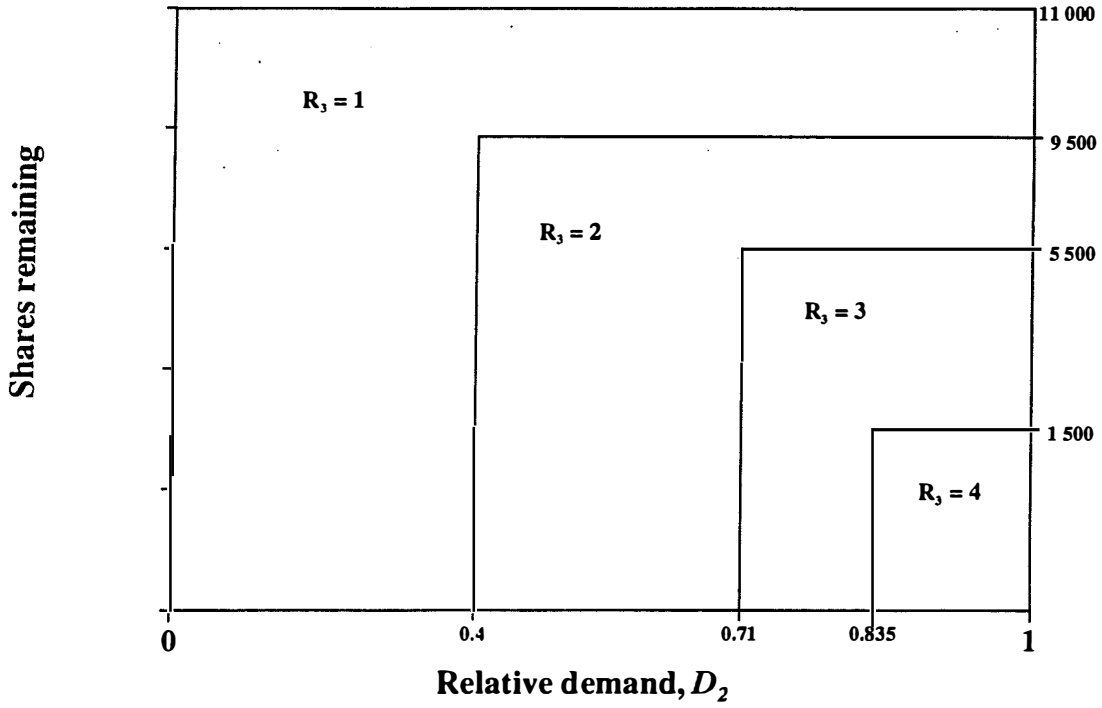
Note: The exact repricing factors are given in Table 22

Figure 2B
Firms with "small leftovers" after the second round



Note: Both figures adapted from Krcmar (1992)
R_3 = repricing factor for the third round
Firms with "small leftovers" are defined as Group 2.5 in Appendix 3

Figure 3
Firms with small leftovers after the second round



Note: Adapted from Krcmar (1992).
R_3 = repricing factor for the third round.
Firms with small leftovers are defined as group 2.5 in Appendix 3.

Table 1

Key events in the first wave of voucher privatization

Start of economic transition program	January 1, 1991
Large privatization law is passed	February 26, 1991
Deadline for basic projects	October 31, 1991
Voucher registration	October 1, 1991 to February 15, 1992
Deadline for competing projects	January 20, 1992
Round 0	February 17 to April 26, 1992
List of 1,491 participating companies is published	May 13, 1992
Round 1	May 18 to June 30, 1992
Round 2	July 8 to August 18, 1992
Round 3	August 26 to October 6, 1992
Round 4	October 14 to November 17, 1992
Round 5	November 23 to December 22, 1992
Czech and Slovak republics split	January 1, 1993
Distribution of shares from first wave begins	May 29, 1993

Table 2
Unconditional cross-sectional distribution of accounting variables

VARIABLE	N	Min	Q1	Median	Mean	Q3	Max	Std
# Shares:	1489	713	333428	71316	201405	179303	14754.374	606639
INS:	1482	.092	.744	.969	.839	.970	1.14	.202
Risk 1	1341	0.0	0.212	.041	.081	.077	10.40	.351
Risk 2	1346	0.0	6.24	12.83	37.68	27.93	9252	262.75
Risk 3	1482	0.0	0.276	.057	.134	.110	58.17	1.51
Sales	1482	379.33	47679	122304	500437	329007	105085333	3143866
Profits	1482	-105817	1813	7744	51859	26489	10543660	363765
Bank debt	1482	0.0	3299	15688	107392	73473	12290164	495971
# Employees	1482	3	175	380	916	886	36593	1916
Assets	1482	1650	46194	98165	381863	267833	56038412	181.365
Total debt	1482	0	15119	59474	429258	188650	216006982	5695704
ROA	1482	-.815	.030	.086	.148	.168	40.49	1.06
Margin	1482	-3.91	.031	.075	.085	.133	.94	.173
Productivity	1482	-193.56	8.69	20.86	46.62	42.09	6681	200.50
Leverage 1	1455	0.0	.153	.332	.812	568	410.23	11.64
Leverage 2	1482	0.0	.063	.171	.284	.329	15.62	.568
Leverage 3	1482	0.0	.236	.509	1.10	.943	75.53	3.21
G profits	1184	-101.23	-.398	-.0472	.974	.563	603.06	22.28
G employ	1234	-.535	-.138	-.0874	-.097	-.044	.446	.092
G bank debt	782	-.160	-.145	.0185	.253	.253	62.14	2.42
G sales	1213	-.696	-.0952	.0246	.065	.155	4.93	.33

Note: After elimination of companies with negative total debt. See Appendix 1 for definitions.
G = growth rate (%).

Table 3

Panel A

Unconditional cross-sectional distribution of the quoted price in each round

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std	# Values
1	1491	33.33	33.33	33.33	33.33	33.33	33.33	0	1
2	1443	10.00	12.50	14.29	38.27	50.00	400.00	49.85	20
3	1370	1.03	4.17	25.00	55.98	50.00	800.00	94.79	40
4	1317	1.17	7.14	25.00	60.97	50.00	1000.00	112.02	65
5	1236	1.67	12.50	33.33	59.65	66.67	1000.00	103.10	57

Panel B

Unconditional cross-sectional distribution of the transaction price in each round

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	1491	33.33	33.33	33.33	33.33	33.33	33.33	33.33
2	1003	10.00	11.11	14.29	42.52	50.00	300.00	52.7
3	863	1.59	20.00	33.33	79.93	100.00	800.00	104.59
4	947	1.69	16.67	33.33	75.94	100.00	1000.00	117.92
5	1118	2.33	14.29	33.33	59.45	66.67	1000.00	94.84

Note: # Values is the number of different values that prices took on in each round.
Transaction price equals the auctioneer's posted price only in round 1.

Table 3

Panel C

Cross-sectional distribution of the quoted prices in each round, conditional on subscription status

Undersubscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	1013	33.33	33.33	33.33	33.33	33.33	33.33	0
2	930	10.00	11.11	14.29	42.81	50.00	300.00	53.86
3	810	1.59	25.00	50.00	82.28	100.00	800.00	105.67
4	866	1.69	20.00	40.00	78.95	100.00	1000.00	116.50
5	1078	2.32	14.29	33.33	61.00	66.67	1000.00	96.15

Oversubscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	430	33.33	33.33	33.33	33.33	33.33	33.33	0
2	440	10.00	14.29	14.29	28.60	25.00	400.00	40.98
3	507	1.03	2.63	4.17	15.22	11.11	800.00	55.08
4	370	1.62	3.57	6.25	22.68	16.62	1000.00	84.03
5	118	1.67	6.25	11.11	61.56	40.00	1000.00	162.26

Fully subscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	48	33.33	33.33	33.33	33.33	33.33	33.33	0
2	73	10.00	14.29	14.29	38.83	50.00	200.00	35.59
3	53	1.59	3.57	16.67	43.94	33.33	400.00	78.74
4	81	2.00	4.35	8.33	43.69	33.33	1000.00	128.57
5	40	2.94	4.54	9.55	17.70	20.00	100.00	21.13

Table 4

Panel A
Unconditional cross-sectional distribution of the relative demand in each round

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	1491	.0037	.169	.514	1.23	1.32	145.40	4.32
2	1443	.0105	.360	.714	1.21	1.32	13.94	1.55
3	1370	.00	.314	.769	1.17	1.68	11.00	1.18
4	1317	.015	.280	.698	.91	1.18	33.18	1.39
5	1236	.027	.283	.489	.66	.81	14.71	.88

Panel B
Cross-sectional distribution of the relative demand in each round conditional on subscription status

Undersubscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	1013	.004	.094	.285	.341	.536	.999	.274
2	930	.011	.228	.473	.469	.677	.996	.271
3	810	.021	.196	.378	.429	.631	.998	.267
4	866	.015	.187	.399	.442	.691	1.00	.288
5	1078	.027	.261	.432	.472	.686	.998	.256

Oversubscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	430	1.00	1.47	2.02	3.35	3.46	145.40	7.63
2	440	1.00	1.40	2.11	2.79	3.51	13.94	2.01
3	507	1.01	1.53	2.06	2.37	2.89	10.99	1.16
4	370	1.01	1.27	1.47	1.96	1.85	33.19	2.26
5	118	1.02	1.22	1.47	2.24	2.22	14.71	2.15

Fully subscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	48	1.00	1.04	1.09	1.11	1.15	1.94	.137
2	73	1.00	1.02	1.05	1.07	1.10	1.37	.065
3	53	.00	1.03	1.06	1.04	1.10	1.19	.166
4	81	1.00	1.03	1.06	1.08	1.11	1.68	.084
5	40	1.00	1.02	1.04	1.05	1.09	1.17	.043

Note: For the fully subscribed stocks, the 0 min value in round 3 refers to a company that was removed from the auction.

Table 4

Panel C

Cross-sectional distribution of the relative demand in each round conditional on investor type

IPFs

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	1491	.00	.046	.343	.669	.870	9.02	.990
2	1443	.00	.066	.352	.540	.717	6.93	.695
3	1370	.00	.014	.315	.506	.766	4.72	.596
4	1317	.00	.00	.159	.309	.525	2.33	.369
5	1236	.00	.00	.044	.152	.229	1.86	.219

Individuals

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
1	1491	.003	.062	.141	.564	.389	137.05	3.80
2	1443	.011	.140	.278	.664	.704	12.42	1.12
3	1370	.00	.173	.349	.664	.879	8.78	.79
4	1317	.00	.179	.380	.599	.649	33.18	1.33
5	1236	.026	.187	.332	.507	.546	13.53	.85

Table 5

Aggregate number of points bid, used and leftover: total and conditional on investor type (points in billions)

Total endowment = 8.59 billion								
Round	Points Bid	Points Used	Points Left	Percentage of Points Left	Points Used/ Points Bid	Points Used/ Σ Points Used	Points Bid/ Points Left	
1	7.93	2.98	5.61	65.29%	65.29 %	35.23 %	92.28 %	--
2	4.88	3.41	2.20	25.62	69.89	40.38	86.94	--
3	1.99	1.02	1.18	13.73	51.28	12.09	90.40	--
4	1.00	0.51	0.68	0.08	51.46	6.08	84.40	--
5	0.56	0.52	0.15	0.02	92.17	6.14	84.14	--
Total	16.35	8.44	--	--	--	100.00	--	
IPF endowment = 6.18 billion								
Round	Points Bid	Points Used	Points Left	Percentage of Points Left	Points Used/ Points Bid	Points Used/ Σ Points Used	Points Bid/ Points Left	Points Bid by Group/ Total Points Bid
1	5.91	2.33	3.85	62.27	39.46 %	38.20 %	92.28 %	74.54 %
2	3.51	2.54	1.30	21.11	72.45	41.68	91.22	71.99
3	1.25	0.71	0.59	9.60	56.80	11.66	96.02	62.98
4	0.55	0.26	0.33	5.36	47.58	4.29	92.75	55.21
5	0.29	0.25	0.07	1.25	88.13	4.17	87.05	51.38
Total	11.51	6.10	--	--	--	100.00	--	--
Individual endowment = 2.41 billion								
Round	Points Bid	Points Used	Points Left	Percentage of Points Left	Points Used/ Points Bid	Points Used/ Σ Points Used	Points Bid/ Points Left	Points Bid by Group/ Total Points Bid
1	2.02	0.65	1.76	73.04	32.92 %	27.80 %	83.74 %	25.46 %
2	1.37	0.86	0.90	37.17	63.30	36.98	77.58	28.01
3	0.74	0.31	0.59	24.38	41.86	13.19	82.20	37.02
4	0.45	0.25	0.34	13.96	56.23	10.74	75.92	44.79
5	0.27	0.26	0.08	0.03	96.41	11.28	81.28	48.62
Total	4.84	2.34	--	--	--	100.00	--	

Table 6

Panel A
Unconditional distribution: number of shares left before and after each round

	ROUND	N	Min	Q1	Median	Mean	Q3	Max x 10^6	Std x 10^5	Sum x 10^6
BEFORE	1	1491	713	33428	71301	200800	179303	14.75	6.05	299.39
AFTER	1	1443	58	20681	49034	145938	127859	9.17	3.93	209.95
AFTER	2	1370	10	9340	30122	96443	73232	6.75	3.16	132.13
AFTER	3	1317	13	5142	19640	75608	55850	6.75	2.85	99.57
AFTER	4	1236	7	2572	9190	50566	32604	6.75	2.54	62.51
AFTER	5	1196	3	1284	3076	18019	12261	1.57	0.72	21.55

Panel B
Cross-sectional distribution: number of shares left after each round, conditional on subscription status

Undersubscribed stocks

	ROUND	N	Min	Q1	Median	Mean	Q3	Max x 10^6	Std x 10^5	Sum x 10^6
AFTER	1	1013	1379	42026	80192	221302	187661	14.75	7.02	224.18
AFTER	2	930	713	29447	67453	178037	179282	9.17	4.33	165.57
AFTER	3	810	58	5996	17759	63039	54081	5.12	2.19	51.06
AFTER	4	866	13	3605	12227	50272	37940	3.21	1.85	43.54
AFTER	5	1078	17	2746	9095	50657	31124	6.75	2.69	54.61

Oversubscribed stocks

	ROUND	N	Min	Q1	Median	Mean	Q3	Max x 10^6	Std x 10^5	Sum x 10^6
AFTER	1	430	713	18657	42862	140050	135141	2.92	2.53	60.22
AFTER	2	440	58	9255	22642	72184	55824	5.12	2.31	31.76
AFTER	3	507	10	25779	49867	151152	117304	6.75	4.32	76.63
AFTER	4	370	36	1426.3	40689	124210	90159	6.75	4.49	45.96
AFTER	5	118	7	541	4053	35213	18004	0.60	0.95	4.15

Fully subscribed stocks

	ROUND	N	Min	Q1	Median	Mean	Q3	Max x 10^6	Std x 10^5	Sum x 10^6
AFTER	1	48	5533	47215	96235	312329	236974	2.74	5.79	14.99
AFTER	2	73	930	29718	65899	172863	132304	2.42	3.77	12.62
AFTER	3	53	1873	17464	44035	83601	83540	0.45	1.08	4.43
AFTER	4	81	26	24578	51740	124465	128748	1.08	1.85	10.08
AFTER	5	40	597	18499	36913	93421	87365	0.73	1.50	3.74

Table 7

Panel A
Frequency and probability of events in two consecutive rounds

Events: O = oversubscribed
U = undersubscribed
F = fully subscribed

Round $j+1 \mid j$ Type		Round 2 | 1	Round 3 | 2	Round 4 | 3	Round 5 | 4	Total
OO	#	49	17	224	12	302
	%	3.4	1.2	17.0	1.0	5.6
OU	#	348	411	213	328	1300
	%	24.1	30.0	16.2	26.5	24.2
OF	#	33	12	70	30	145
	%	2.3	0.9	5.3	2.4	2.7
UU	#	582	399	653	750	2384
	%	40.3	29.1	49.6	60.7	44.4
UO	#	391	490	146	106	1133
	%	27.1	35.8	11.1	8.6	21.1
UF	#	40	41	11	10	102
	%	2.8	3.0	0.8	0.8	1.9
Total	#	1443	1370	1317	1236	5366
	%	100.0	100.0	100.0	100.0	100.0

Panel B
Number of times a stock was undersubscribed in the five rounds

#	# Events	Frequency (%)
0	0	0.00
1	3	0.25
2	61	5.10
3	368	30.77
4	693	57.94
5	71	5.94
Total	**1196**	100.00%

Note: for stocks not fully subscribed before round 5

Table 8

Frequency and percentage of mispriced stocks

Group	Round 2		Round 3		Round 4		Round 5		Total
1	426	(29.52%)	414	(30.22%)	416	(31.59%)	367	(29.69%)	(30.25%)
2	939	(65.07%)	631	(46.06%)	102	(7.74%)	286	(23.14%)	(36.49%)
3	4	(0.00%)	26	(1.90%)	91	(6.91%)	3	(00.00%)	(2.31%)
4	74	(5.13%)	299	(21.82%)	708	(53.76%)	580	(46.92%)	(30.95%)
Total	1443	100.00%	1370	100.00%	1317	100.00%	1236	100.00%	100.00%

Note: Group 1 = Oversubscribed stocks whose price was increased.
Group 2 = Undersubscribed stocks whose price was decreased.
Group 3 = Oversubscribed stocks whose price was decreased.
Group 4 = Undersubscribed stocks whose price was increased.

Table 9

Cross-sectional distribution of the ratio of relative demand and the subsequent repricing factor M=D/R as a proxy for mispricing

Unconditional : Pooled undersubscribed and oversubscribed

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
2	1443	.0122	.391	.952	.820	1.11	12.12	.552
3	1370	.0700	.476	.986	.950	1.27	3.00	.493
4	1312	.0228	.303	.622	.833	1.27	7.83	.626
5	1236	.0292	298	.497	.568	0.91	12.33	.499

Conditional : Oversubscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
2	430	.174	1.02	1.06	1.13	1.14	12.12	.584
3	930	.631	.983	1.08	1.21	1.33	3.01	.349
4	507	.507	1.18	1.42	1.53	1.83	7.83	.565
5	370	.544	.943	.996	1.03	1.04	12.35	.684

Conditional : Undersubscribed stocks

ROUND	N	Min	Q1	Median	Mean	Q3	Max	Std
2	1013	.012	.266	625	.687	1.03	2.22	.481
3	440	.070	.363	785	.825	1.20	2.91	.502
4	810	.023	.211	354	.399	.556	.99	.232
5	866	.291	.239	394	.368	.504	.74	.155

Table 10

Results of the logistic and OLS regressions with the stepwise selection technique

	Logistic		OLS		OLS		OLS	
Dependent Variable	**Subscription Status, O**		**Aggregate Demand, D**		**Individual Demand, IND**		**IPF Demand, IPF**	
Variable Name	**Estimate**	**p-Val**	**Estimate**	**p-Val**	**Estimate**	**p-Val**	**Estimate**	**p-Val**
Intercept	9.05	.0001	4.91	.0001	2.53	.0001	3.00	.0001
Industry dummy 1	–	--	–	–	–	--	-.207	.0239
Industry dummy 3	.677	.0008	.317	.0003	–	--	.195	.0001
Industry dummy 4	–	--	–	–	–	--	-.143	.0076
Industry dummy 8	1.21	.0104	-4703	.0146	.256	.0162	–	–
INS	-4.54	.0001	-1.288	.0001	-.381	.0264	-1.213	.0001
SHARE	–	--	-.187	.0007	-.173	.0001	-.0803	.0050
ROA	3.44	.0001	2.07	.0001	1.045	.0001	1.072	.0001
Lev1	-.0124	.0355	–	–	–	--	–	–
Lev3	--	--	-.0911	.0003	-.0409	.0002	-.054	.0001
Tdebt	-.651	.0001	-.118	.0052	–	--	-.0832	.0001
Profits	.341	.0001	.0584	.0008	–	--	.0575	.0001
Risk 2	–	--	.0025	.0072	.0011	.0123	.0022	.0001
Risk 3	–	--	.7486	.0264	–	--	–	–
G sales	.785	.0407	–	--	–	--	.166	.0287
G employ	--	--	1.29	.0026	–	--	–	–
EMPLOY	-.316	.0180	–	–	–	--	–	–
ASSETS	--	--	.506	.0003	.301	.0001	–	–
DCS	–	--	–	--	.0866	.0426	–	–
Adjusted R^2	N.A.		.425		.300		.456	
% correctly classified as oversubscribed	87.3%		N.A.		N.A.		N.A.	
% incorrectly classified as undersubscribed	12.5%		N.A.		N.A.		N.A.	

Note: Log transformation has been applied to the following variables: SHARE, Tdebt, EMPLOY, ASSETS.
For the variable Profits, 10 groups of equal size were formed by ascending order.
N.A. = not applicable

Table 11

Median relative demand conditional on relative demand in the previous round, segmented in 12 groups: rounds 2-5 ($D_{j+1} \mid D_j$)

Group		Median Relative Demand, $D_{j+1} \mid D_j$							
		Round D2 | D1		Round D3 | D2		Round D4 | D3		Round D5 | D4	
		Median D_1	Median D_2	Median D_2	Median D_3	Median D_3	Median D_4	Median D_4	Median D_5
U	1	.029	.146	.087	1.19	.099	.098	.084	.184
	2	.093	.319	.227	1.77	.194	.212	.186	.279
	3	.215	.536	.381	1.33	.309	.298	.315	.342
	4	.359	.975	.541	1.08	.469	.497	.482	.506
	5	.537	2.07	.677	1.23	.632	.702	.691	.586
	6	.808	3.01	.871	.630	.857	1.02	.891	.895
O	7	1.19	.931	1.08	.793	1.14	.982	1.07	.554
	8	1.36	.747	1.25	.642	1.39	.979	1.18	.845
	9	1.64	.716	1.55	.523	1.76	1.03	1.31	.798
	10	2.20	.697	2.17	.349	2.76	1.10	1.47	.737
	11	3.27	.601	3.30	.347	2.76	1.02	1.73	.751
	12	5.51	.515	5.48	.321	3.89	1.37	2.59	.400
Unconditional median		.514	.714	.714	.769	.769	.698	.698	.489
X^2 Statistic		479.13		333.86		581.14		456.00	

Note: The p-value of the χ^2 statistic is less than 0.001 in all cases.

Table 12

Median relative demand of IND in round j+1 conditional on the relative demand of IND and IPF in round j

$(IND_{j+1} \mid IND_j, IPF_j)$

IPF: / IND	1	2	3	4	5	6	7	8	9	10	Conditional on IND_j
1	56 .077	22 .121	28 .067	19 .067	6 .094	10 .226	3 .283	—	—	—	144 .084
2	23 .104	24 .115	28 .104	25 .155	16 .177	12 .208	11 .432	4 1.68	1 .04	—	144 .147
3	24 .124	18 .148	21 .207	17 .208	18 .178	22 .442	16 .771	7 1.30	2 .411	—	145 .231
4	19 .160	14 .499	16 .203	20 .208	16 .474	20 .496	21 .892	12 1.15	6 .060	—	144 .388
5	12 .144	10 .253	16 .215	17 .491	26 .336	21 .760	20 1.25	16 1.13	6 .089	—	144 .475
6	5 .276	12 .459	12 .349	19 .366	21 .542	13 .955	17 1.53	18 .998	20 .108	2 .083	145 .482
7	5 .247	20 .934	11 .495	15 .597	11 1.96	17 1.71	18 2.30	18 .323	23 .127	6 .094	144 .686
8	—	13 1.48	6 1.24	5 2.62	17 1.77	11 1.83	15 1.70	31 .311	29 .191	18 .106	145 .376
9	—	5 2.05	6 2.17	4 1.32	8 3.14	10 .59	15 .59	25 .401	33 .240	38 .159	144 .323
10	—	6 .636	1 .571	3 .554	5 .835	3 .325	8 .510	14 .419	24 .332	80 .190	144 .275
Uncondi-tional	144 .107	144 .365	145 .189	144 .251	144 .452	145 .565	144 1.00	145 .484	144 .187	144 .159	1443 .279

Median relative demand of IPF in round j+1 conditional on the relative demand of IND and IPF in round j

$(IPF_{j+1} \mid IPF_j, IND_j)$

IPF / IND	1	2	3	4	5	6	7	8	9	10	Conditional on IPF_j
1	56 .00	23 .100	24 .028	19 .027	12 .00	5 .00	5 .204	—	—	—	144 .0085
2	22 .00	24 .00	18 046	14 .226	10 .066	12 .019	20 .080	13 .015	5 .133	6 .004	144 .0359
3	28 .085	28 .085	21 .219	16 .207	16 .078	12 .112	11 .224	6 1.54	6 .284	1 .00	145 .179
4	19 .078	25 .288	17 .267	20 245	17 240	19 .581	15 .755	5 .696	4 .174	3 .00	144 .265
5	6 .188	16 .357	18 420	16 431	26 495	21 733	11 1.11	17 .527	8 .984	5 .088	144 .480
6	10 .329	12 .410	22 584	20 584	21 1 02	13 799	17 1.02	11 1.24	10 .288	3 .014	145 .642
7	3 .98	11 .83	16 1 01	21 1 01	20 2.15	17 1.17	18 1.84	15 .242	15 .160	8 .317	144 .961
8	—	4 2.85	7 1 71	12 214	16 1 074	18 .333	18 .505	31 .461	25 .366	14 .054	145 .449
9	—	1 .560	2 775	6	6 508	20 .615	23 .604	29 .503	33 .375	24 .192	144 .495
10	—	—	—	—	—	2 .346	6 .732	18 .679	38 .434	80 .370	144 .411
Uncondi-tional	144 .052	144 .214	145 .267	145 429	144 .533	144 .558	145 .610	144 .503	145 .363	144 .252	1443 .352

Note: IND_j in rows, and IPF_j in columns

The first entry in each cell gives the number of observations; the second entry reports the median value.

Table 13

Median relative demand conditional on number of shares left before the auction (NS) segmented in 12 groups by investor type: rounds 1-5 ($IND_{j+1} \mid NS_j$), ($IPF_{j+1} \mid NS_j$)

	Round 1			Round 2			Round 3			Round 4			Round 5		
Group	Median NS_0	Median IND_1	Median IPF_1	Median NS_1	Median IND_2	Median IPF_2	Median NS_2	Median IND_3	Median IPF_3	Median NS_3	Median IND_4	Median IPF_4	Median NS_4	Median IND_5	Median IPF_5
1	7 89	91	41	3 26	1 12	21	1 19	.25	.00	.52	.35	.00	.22	.51	.00
2	17 95	42	48	9 97	80	24	4.30	.24	.00	2.01	.28	.00	.94	.38	.00
3	28 31	24	38	17 45	60	38	7.63	.20	.00	3.89	.24	.00	2.02	.33	.00
4	38 34	18	31	24 01	.46	.49	12.37	.32	.22	6.40	.21	.02	3.26	.30	.00
5	49 81	12	31	31 99	.35	.38	18.74	.47	.39	10.89	.39	.11	4.92	.30	.01
6	62 80	13	22	42 05	25	.46	25.12	.34	.29	16.34	.42	.19	7.31	.32	.03
7	81 07	10	28	57 01	21	26	35.04	.47	.43	23.38	.46	.17	10.85	.30	.05
9	147 38	10	26	103 72	22	42	63.33	.44	.48	46.18	.53	.41	23.64	.37	.10
10	224 13	08	34	158 58	15	40	92.24	.48	.63	69.08	.43	.47	40.74	.35	.19
11	363 79	08	34	272 49	13	22	170.42	.46	.55	118.45	.43	.44	70.48	.30	.22
12	782 74	08	44	600 26	.12	.41	392.64	.66	.71	303.78	.48	.54	222.40	.36	.36
Uncondi - tional median	71 30	141	343	49 03	.278	.352	30.12	.349	.315	19.64	.380	.159	9.19	.332	.044
X^2 statistic		261.92	13.03		450.69	34.98		127.87	280.92		94.33	341.47		29.14	431.6

Notes: NS_j = # of shares x 10^{-3}.

NS_0 = the number of shares outstanding before round 1.

The p-value of the X^2 statistic is less than 0.001 in all cases except for IPF_1.

Table 14

Median relative demand conditional on price segmented in 12, 11, or 20 groups by investor type: rounds 2-5

$(IND_{j+1} \mid P_j)$, $(IPF_{j+1} \mid P_j)$

	INDIVIDUALS								IPF's							
Group	Round 2 Medians		Round 3 Medians		Round 4 Medians		Round 5 Medians		Round 2 Medians		Round 3 Medians		Round 4 Medians		Round 5 Medians	
	P_1	IND_2	P_2	IND_3	P_3	IND_4	P_4	IND_5	P_1	IPF_2	P_2	IPF_3	P_3	IPF_4	P_4	IPF_5
1	10.00	.09	1.96	.82	2.38	.95	4.00	.61	10.00	.00	1.96	.43	2.38	.35	4.00	.20
2	11.11	.13	2.50	.92	3.85	.67	6.25	.53	11.11	.07	2.50	.68	3.85	.52	6.25	.20
3	12.50	.21	3.57	1.16	5.88	.59	5.09	.53	12.50	.06	3.57	.88	5.88	.44	9.09	.21
4	14.29	.53	4.76	1.25	9.09	.53	14.28	.43	14.29	.57	4.76	.95	9.09	.49	14.28	.05
5	16.67	1.84	14.29	.48	16.67	.53	20.00	.30	16.67	1.78	14.29	.45	16.67	.24	20.00	.06
6	20.00	1.92	20.00	.24	25.00	.30	25.00	.23	20.00	1.17	20.00	.41	25.00	.26	25.00	.04
7	25.00	1.68	25.00	.24	33.33	.25	33.33	.24	25.00	1.20	25.00	.31	33.33	.10	33.33	.03
8	33.33	1.21	33.33	.27	40.00	.20	40.00	.25	33.33	.47	33.33	.24	40.00	.13	40.00	.02
9	37.50	.68	50.00	.20	50.00	.21	50.00	.29	37.50	.41	50.00	.05	50.00	.09	50.00	.01
10	40.00	.37	100.00	.15	66.66	.35	66.66	.21	40.00	.48	100.00	.02	66.66	.15	66.66	.00
11	42.86	.22	200.00	.15	100.00	.16	100.00	.24	42.86	.56	200.00	.00	100.00	.01	100.00	.00
12	50.00	.28			200.00	.13	200.00	.23	50.00	.47			200.00	.00	200.00	.00
13	60.00	.22							60.00	.39						
14	66.66	.20							66.66	.50						
15	75.00	.26							75.00	.38						
16	100.00	.24							100.00	.24						
17	150.00	.14							150.00	.38						
18	200.00	.31							200.00	.10						
19	300.00	.22							300.00	.31						
20	400.00	2.71							400.00	.22						
Unconditional median	14.29	.28	25.00	.35	25.00	.380	33.33	.332	14.29	.35	25.00	.315	25.00	.159	33.33	.045
X^2 statistic	391.37		567.36		446.92		248.38		312.58		314.09		282.65		121.12	

Note: The p-value of the X^2 statistic is less than 0.001 in all cases.

Table 15

Median relative demand in round j, the repricing factor Rj, the ratio of the former to the latter, and the relative demand in round j+1, total and segmented by investor type

Unconditional

Round	N	Median D_j	Median R_j	Median $M_j = D_j/R_j$	Median D_{j+1}	Median IND_{j+1}	Median IPF_{j+1}
2	1443	.490	.420	.952	.714	.279	.352
3	1350	.666	1.00	.982	.762	.399	.315
4	1312	.724	1.00	.623	.698	.380	.159
5	1236	.748	1.20	.492	.489	.332	.044

Conditional: oversubscribed stocks

Round	N	Median D_j	Median R_j	Median $M_j = D_j/R_j$	Median D_{j+1}	Median IND_{j+1}	Median IPF_{j+1}
2	430	2.02	2.00	1.065	.665	.223	.417
3	440	2.11	2.00	1.081	.421	.200	.173
4	507	2.06	1.50	1.419	1.07	.521	.513
5	370	1.47	1.50	.996	.725	.375	.244

Conditional: undersubscribed stocks

Round	N	Median D_j	Median R_j	Median $M_j = D_j/R_j$	Median D_{j+1}	Median IND_{j+1}	Median IPF_{j+1}
2	1013	.420	.625	.758	.358	.300	.094
3	930	.472	4 10	.785	1.188	.606	.478
4	810	.378	1 00	.355	.388	.240	.031
5	866	.399	1 00	.394	.395	.307	.000

Table 16

Median values for the mispricing proxy M_j split into 10 groups, the unconditional relative demand in the subsequent round D_{j+1}, and relative demand, segmented by investor type $(D_{j+1} \mid M_j)$, $(IND_{j+1} \mid M_j)$, $(IPF_{j+1} \mid M_j)$

	Round 2				Round 4			
GROUP	M_j	D_{j+1}	IND_{j+1}	IPF_{j+1}	M_j	D_{j+1}	IND_{j+1}	IPF_{j+1}
1	.084	.135	.086	.007	.112	.094	.076	.000
2	.222	.363	.151	.067	.207	.216	.160	.005
3	.391	.383	.217	.097	.302	.306	.237	.016
4	.611	.770	.300	.237	.398	.440	.319	.038
5	.833	1.03	.496	.473	.536	.579	.360	.086
6	.995	.704	.263	.440	.717	.913	.626	.195
7	1.04	.723	.278	.437	.991	1.03	.653	.332
9	1.22	1.17	.482	.615	1.55	1.02	.466	.534
10	1.49	2.35	1.22	1.05	2.05	1.35	.606	.656
Unconditional median	.952	.714	.279	.352	.623	.698	.380	.159

	Round 3				Round 5			
GROUP	M_j	D_{j+1}	IND_{j+1}	IPF_{j+1}	M_j	D_{j+1}	IND_{j+1}	IPF_{j+1}
1	.239	.207	.167	.000	.122	.169	.123	.00
2	.339	.314	.212	.016	.215	.257	.187	.02
3	.476	.734	.362	.215	.298	.331	.273	.00
4	.826	1.19	.625	.552	.393	.377	.292	.01
5	.950	.722	293	.433	.481	589	.512	.00
6	1.03	.739	.325	.320	.513	.864	.698	.03
7	1.11	.862	.324	.389	.555	.623	.537	.00
8	1.27	1.03	413	.493	.906	.649	.384	.13
9	1.43	1.52	688	.519	.996	.719	.429	.22
10	1.68	1.51	531	624	1.02	.791	.336	.44
Unconditional median	.987	.769	349	.315	.492	.489	.332	.0439

Table 17

Logistic regressions in each round of the subscription status O/U_{j+1} on the proxy for mispricing M_j, the price level P_j, and the number of shares left NS_j, with group dummies

$$1_{\{Dj+1>1.0\}} = \sum_{i=1}^{i=4} \alpha_{jj} + \sum_{i=1}^{i=4} \beta_{i,j} M_j + \sum_{i=1}^{i=4} \gamma_{i,j} P_j + \sum_{i=1}^{i=4} \delta_{i,j} NS_j + \varepsilon_j, \text{ with } j = 2,..,5.$$

		Round 2		Round 3		Round 4		Round 5	
Statistic		**Estimate**	***p*-Val**	**Estimate**	***p*-Val**	**Estimate**	***p*-Val**	**Estimate**	***p*-Val**
Intercept	α1	.005	.996	-2.28	.223	-4.99	.0001	-7.66	.0013
	α2	2.29	.0689	-.443	.726	-.158	.963	-3.17	.481
	α3	—	—	.393	.960	-.764	.766	—	—
	α4	19.66	.0037	4.59	.0027	-4.94	.0001	-2.398	.0181
Mispricing, M	β1	.629	.1631	-.969	.203	1.30	.0001	2.82	.1467
	β2	3.63	.0001	2.47	.0001	4.77	.0003	16.55	.0475
	β3	—	—	-7.53	.159	1.103	.0289	—	—
	β4	-1.19	.683	6.41	.0013	5.411	.0001	7.79	.0001
Price, P	γ1	-.0058	.0286	.00168	.471	.00298	.0805	.00311	.1534
	γ2	.0533	.3277	-.0291	.0001	-.0391	.0096	-.0046	.4365
	γ3	—	—	-.0046	.717	.00596	.631	—	—
	γ4	-.0396	.0177	-.0023	.222	-.00392	.0363	-.0061	.0073
Number of shares, NS	δ1	-.162	.049	.565	.701	.311	.0005	.249	.0389
	δ2	-.563	.0001	-.0121	.9025	-.174	.5658	-.568	.1717
	δ3	—	—	.753	.2019	-.0915	.6861	—	—
	δ4	-.176	.0043	-1.138	.0001	.1265	.0975	-.298	.0001
	1	86.7%		93.0%		83.0%		78.2%	
	2	13.2%		6.8%		16.8%		21.4%	

Group 1: Oversubscribed stocks for which repricing factor was increased.
Group 2: Undersubscribed stocks for which repricing factor was decreased.
Group 3: Oversubscribed stocks for which repricing factor was decreased.
Group 4: Undersubscribed stocks for which repricing factor was increased.
1: Percentage of companies correctly classified as oversubscribed.
2: Percentage of companies incorrectly classified as undersubscribed.

Table 18

Median price in round 5 conditional on the median relative demand in round 1, D_1 and the number of shares outstanding before the auction, NS_0: for companies not fully subscribed before round 5 ($P_5 | D_1, NS_0$)

D_1	NS_0:	1	2	3	4	5	6	7	8	9	10	Uncondi-tional
U	1	3 20.00	2 18.33	13 7.69	13 7.14	19 6.66	33 6.25	20 6.07	29 5.88	23 4.55	22 4.08	177 5.88
U	2	3 50.00	11 20.00	21 11.11	15 12.50	26 10.55	21 7.69	22 11.81	19 10.00	20 7.14	19 5.26	177 10.00
U	3	13 33.33	21 25.00	21 25.00	21 16.66	17 16.66	10 15.48	20 20.00	18 15.48	19 14.29	17 16.67	177 20.00
U	4	13 33.33	15 40.00	14 29.17	27 25.00	19 20.00	17 33.33	17 25.00	16 25.00	19 33.33	20 20.00	177 25.00
U	5	16 83.33	19 50.00	14 45.00	16 45.00	22 66.66	18 40.00	20 45.00	16 50.00	24 40.00	12 29.17	177 50.00
O	6	9 50.00	14 58.33	13 40.00	5 33.33	3 33.33	6 40.00	3 50.00	6 45.00	3 33.33	8 29.11	70 40.00
O	7	16 83.33	6 50.00	7 66.67	6 83.33	3 100.00	3 66.66	5 50.00	3 33.33	9 50.00	12 33.33	70 66.66
O	8	21 100.00	10 100 00	10 83.33	3 33.33	5 50.00	7 40.00	6 58.33	4 45.00	0	5 50.00	71 66.66
O	9	11 100.00	12 100.00	9 100.00	6 58.33	7 66.66	3 66.66	8 66.66	5 66.66	2 70.00	7 100.00	70 100.00
O	10	18 200.00	14 200 00	2 200.00	11 200 00	3 200.00	6 100.00	2 66.66	8 100.00	5 150.00	1 150.00	70 175.00
Uncondi-tional median		123 100.00	124 50 00	124 33.33	123 25 00	124 20 00	124 16.66	123 25.00	124 25.00	124 25.00	123 25.00	1236 33.33

Notes:
- Relative demand in columns and number of shares in rows.
- Relative demand sorted into 10 groups, the first five for undersubscribed stocks, and the last five for oversubscribed stocks
- The first number in each cell gives the number of observations, and the second number the median price in round 5.
- Groups created in ascending order of the variable.

Table 19
Median price and subscription path in round 5 for companies not fully subscribed before round 5

Path Number		Number of Events, N	Subscription Path	Median Relative Demand in Round 1 D_1	Median Number of Shares before Round 1 NS_0	Median Price at Round 5, P_5	Median Shares Left after Round 5 NS_5	Median Shares Left after Round 5, in percent, NS_5 (%)
O	1	2	OOOOU	74.41	18860	575.00	1069	9.42
	2	8	OOUOU	1.35	17456	100.00	1483	4.13
	3	2	OOUUO	2.26	404152	150.00	1565	4.30
	4	32	OOUUU	1.47	21049	83.33	2056	10.81
	5	1	OUOOO	1.44	1461069	25.00	391721	26.81
	6	32	OUOOU	1.65	245227	40.00	14583	7.02
	7	6	OUOUO	1.67	210421	58.33	1106	.352
	8	35	OUOUU	1.78	114060	40.00	4070	3.18
	9	1	OUUOO	12.04	10217	1000.00	78	.763
	10	16	OUUOU	2.81	184891	100.00	11043	8.34
	11	7	OUUUO	1.58	22691	200.00	169	.586
	12	204	OUUUU	2.61	26371	100.00	2673	11.01
U	13	2	UOOOU	.098	40557	20.00	12468	34.41
	14	1	UOOUO	.079	27000	25.00	1761	6.52
	15	9	UOOUU	.469	35594	33.33	3098	6.26
	16	37	UOUOU	.307	46117	33.33	2787	6.54
	17	13	UOUUO	.451	40636	66.66	217	.365
	18	307	UOUUU	.598	66037	33.33	5526	8.63
	19	9	UUOOO	.072	105977	5.88	68394	71.56
	20	151	UUOOU	.114	85369	7.69	11523	9.38
	21	67	UUOUO	.103	95099	7.14	9566	9.19
	22	92	UUOUU	.177	136241	12.50	2213	1.92
	23	1	UUUOO	.970	317151	900.00	12	.00
	24	80	UUUOU	052	105714	6.25	11563	8.96
	25	10	UUUUO	220	104705	26.67	1420	1.80
	26	71	UUUUU	.309	41792	33.33	1015	2.47
Unconditional median		1236	---	491	67207	33.33	3736	6.66

Note: O(U) indicates subscription status--oversubscribed (undersubscribed)--in round 1.

Table 20

Median price in round 5 and number of times a company was undersubscribed for companies not fully subscribed before round 5

Group	Number of Events, N	Median Relative Demand in Round 1, D_1	Median Number of Shares before Round 1, NS_0	Median Price at Round 5, P_5	Median Shares Left after Round 5, NS_5
1	3	3.43	35519	150.00	1837
2	61	1.57	101755	40.00	11082
3	368	.246	84276	14.29	5959
4	693	.638	59606	33.33	3735
5	71	.310	41797	33.33	1015
Unconditional median	1236	.491	67207	33.33	3736

Group 1: Stock undersubscribed 1 time.
Group 2: Stock undersubscribed 2 times.
Group 3: Stock undersubscribed 3 times.
Group 4: Stock undersubscribed 4 times.
Group 5: Stock undersubscribed 5 times.

Table 21

Cross-sectional distribution of price differential for subsample of stocks fully subscribed before or in round *j*

Unconditional distribution

	N	Min	Q1	Median	Mean	Q3	Max	Std
All	295	-75.0	-16.68	-7.14	-1.42	-2.31	950	70.38

Conditional distribution: conditional on round

Round	N	Min	Q1	Median	Mean	Q3	Max	Std
1	48	-33.33	-16.62	-16.67	-17.01	-16.62	-16.62	2.41
2	73	-35.72	-10.72	-7.14	-5.73	.00	150.00	21.80
3	53	-75.00	-16.62	-4.13	5.60	.00	300.00	59.38
4	81	-66.67	-25.00	-10.00	7.74	-2.84	950.00	123.08
5	40	-33.33	-5.00	-2.25	-2.70	.46	25.00	10.58

Note: The price differential is computed as the difference between the price of a stock in the round in which it becomes fully subscribed and the median price in round 5 of a control group of companies with similar relative demand in round 1; 10 groups of equal size are formed.

Table 22
The price-updating rule after round 1

Price #	Sample Size, N	Shares Outst. before Round 1, Median, NS_0	Relative Demand in Round 1, D_1			# Shares Left after Round 1, Median, NS_1	Repricing Factor after Round 1, R_2	Price in Round 2, P_2	Relative Demand in Round 2, Median, D_2	# Shares Left after Round 2, Median, NS_2
			Min	Max	Median					
1	88	148097	.004	.094	.017	146322	.30	10.00	.124	105769
2	184	848000	.030	.192	.062	79309	.33	11.11	.256	59587
3	134	82022	.100	.199	.144	70544	.38	12.50	.380	43052
4	478	79771	.200	.933	.412	42040	.43	14.29	1.19	26106
5	13	113696	.672	.860	.689	33856	.50	16.67	3.45	33856
6	19	68256	.691	1.13	.719	19434	.60	20.00	3.46	18579
7	25	56078	.735	1.19	.761	13406	.75	25.00	3.07	12699
8	42	17778	.781	1.05	.828	6548	1.00	33.33	2.17	4939
9	6	29256	1.09	1.16	1.14	29256	1.13	37.50	.912	8492
10	27	32720	1.19	1.50	1.24	32720	1.20	40.00	.780	14053
11	57	76776	1.28	1.54	1.36	76776	1.29	42.86	.749	16775
12	94	69794	.89	3.24	1.56	43946	1.50	50.00	.808	9077
13	35	31954	1.73	2.01	1.86	31954	1.80	60.00	.610	16702
14	35	67134	2.01	2.79	2.18	67334	2.00	66.67	.725	15784
15	46	27599	2.27	3.44	2.52	27599	2.25	75.00	.746	7695
16	67	52033	.92	6.93	3.38	39964	3.00	100.00	.609	14587
17	45	63585	3.22	5.74	4.66	63585	4.50	150.00	.488	29755
18	32	29178	.95	8.31	6.06	9391	6.00	200.00	.556	6189
19	14	18437	8.79	24.32	11.47	18437	9.00	300.00	.558	10993
20	2	2725	44.63	145.40	95.01	2725	12.00	400.00	2.93	2725
Unconditional median	Σ = 1.443	71301	.004	145.40	.514	49034	-	14.29	.714	30122

Note: The price in round 2 is equal to the repricing factor times the price in round 1; the latter is 33.33 points for all companies.

Table 23

The price-updating rule after round 2: summary statistics on price, demand, and number of shares

	Round 1					Round 2					
Group	Shares Left before Median	Relative Demand Min	Relative Demand Max	Relative Demand Median	Shares Left After Median	Sample Size	Price Median	Relative Demand Min.	Relative Demand Max.	Relative Demand Median	Shares Left after Median
2.1	34833	1.01	145.40	1.70	32327	82	60.00	1.01	6.11	1.20	2358
2.2	59670	.013	999	.546	25124	431	14.29	1.00	13.94	2.13	21381
2.3	71234	3.01	17.53	4.33	71234	73	150.00	.13	.915	.457	39326
2.4	134714	1.19	2.98	1.62	134714	127	50.00	.10	.969	.604	45000
2.5	23415	.09	24.32	1.40	17896	248	50.00	.17	.996	.752	4516
2.6	110438	.004	.607	.102	96752	482	12.50	.01	.906	.263	60791
Unconditional	71301	.004	145.40	.514	49034	= 1443	14.29	.011	13.94	.714	30122

	Round 3					Round 4				
Group	Sample Size	Repricing Factor Median	Price Median	Relative Demand Median	Shares Left After Median	Sample Size	Repricing Factor Median	Price Median	Relative Demand Median	Shares Left After Median
2.1	49	1.33	100.00	.570	566	47	1.00	100.00	.506	129
2.2	391	2.33	33.33	.409	10028	381	1.00	33.33	.379	5800
2.3	73	1.00	200.00	.249	27707	68	.66	100.00	.410	11314
2.4	127	.44	25.00	1.50	32350	115	1.00	25.00	1.01	9326
2.5	248	2.00	100.00	.285	2675	249	1.00	100.00	.239	1920
2.6	482	.237	2.94	1.90	47983	462	1.56	5.00	1.18	21175
Unconditional	= 1370	—	25.00	.769	19640	= 1317	—	25.00	698	9190

	Round 5				
Group	Sample Size	Repricing Factor Median	Price Median	Relative Demand Median	Shares Left After Median
2.1	44	1.00	100 00	.426	84
2.2	375	1.00	33.33	.343	3190
2.3	67	1.00	100 00	.359	7854
2.4	96	1.50	40 00	.525	2762
2.5	238	1.00	100 00	296	1304
2.6	416	1.50	7 69	839	5078
Unconditional	= 1236	—	33 33	489	1976

Note Group 2.1: OU

Group 2.2: OU

Group 2.3: OU with $D_1 > 3$ after round 1

Group 2.4: OU with $D_1 \geq 3$ after round 1

Group 2.5: OU or UU with small leftovers

Group 2.6: UU

The first letter refers to the subscription status on round 1 (O/U), and the second letter to the subscription status in round 2.